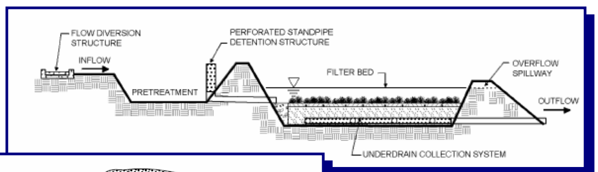
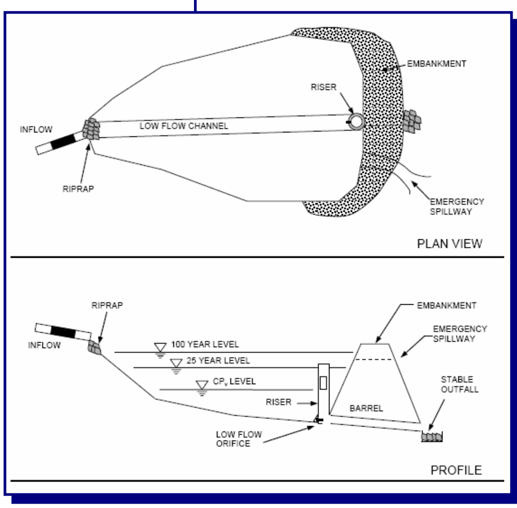
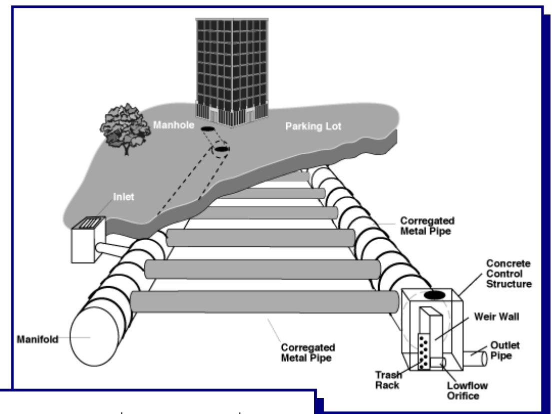
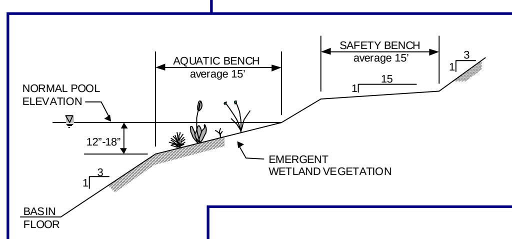
integrated Storm Water Management

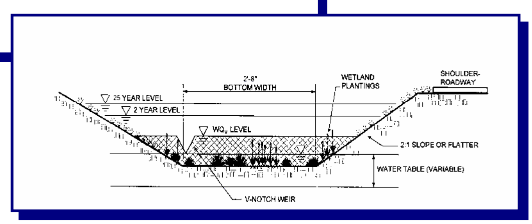
Big Fossil Creek Watershed Study











February 2005

This report was prepared by AMEC for the North Central Texas Council of Governments. The purpose of this study is to provide a quantitative analysis to determine the impacts of implementing iSWM for development in North Texas. The report was reviewed by the Technical Review Team as well as the iSWM Steering Committee.

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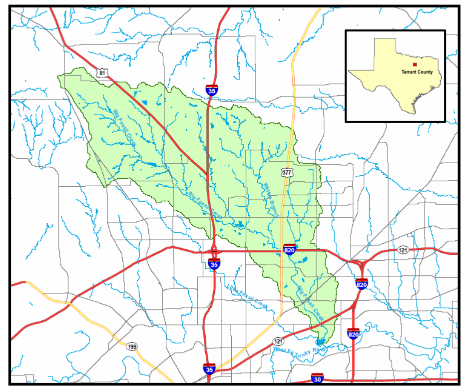
Executive Summary

The benefits of integrated Storm Water Management (iSWM) may be extended beyond the individual site planning level to the watershed level when applied consistently throughout the development of a watershed. The Big Fossil Creek Watershed, located in the northwestern portion of the North Central Texas Council of Governments (NCTCOG) region, was selected to apply simulated development utilizing the iSWM design criteria and watershed models (see figure below). The purpose was to test the potential impacts of iSWM application to the remaining undeveloped portions of Big Fossil Creek compared to development without iSWM practices.

The Big Fossil Creek Watershed covers an area of approximately 56 square miles and encompasses Big Fossil Creek, four un-named tributaries, and Whites Branch. Residential, commercial, and industrial development has primarily occurred in the lower portion of the watershed, leaving the undeveloped upper portion a prime location to simulate iSWM design criteria and verify watershed wide benefits.



Big Fossil Creek Watershed

The iSWM simulation within the Big Fossil Creek Watershed focused on the analysis of the iSWM design criteria in achieving the goals of flood control, water quality, and streambank protection for three watershed scenarios:

- existing watershed conditions;
- future conditions *without* the application of iSWM design criteria; and
- future conditions *with* the application of iSWM design criteria.

Results

The table below compares the results of the three watershed scenarios for each of the four iSWM design criteria goals: (1) runoff quantity flood control; (2) floodplain impact flood control; (3) water quality; and (4) streambank protection. It can be noted the increase from existing conditions to future conditions is consistently reduced with the application of iSWM design practices.

iSWM Design Goals	**Watershed Conditions**					
	Existing	**Future without iSWM**	**Increase from Existing to Future**	**Future *with* iSWM**	**Increase from Existing to Future *with* iSWM**	**Increase from Future to Future *with* iSWM**
Flood Control Analysis – Runoff Quantity						
100-Yr Peak Discharge Upstream of SH 121	34,204 cfs	38,026 cfs	+ 11%	34,639 cfs	+ 1%	- 9%
1-Yr Peak Discharge Upstream of SH 121	5,742 cfs	8,576 cfs	+ 49%	5,054 cfs	- 12%	- 41%
Flood Control Analysis – Floodplain Impact						
Flood Elevation Cross Section # 1	512.66 ft	513.98 ft	1.32 ft	512.81 ft	0.15 ft	- 1.17 ft
Flood Elevation Cross Section # 2	564.77 ft	567.49 ft	2.72 ft	565.47 ft	0.70 ft	- 2.02 ft
Water Quality Analysis						
Total Annual TSS Loading	7,692,556 lbs	11,395,189 lbs	+ 32%	9,714,227 lbs	+18%	-17%
Streambank Protection Analysis (ft)						
Channel Width (ft)	73.00 ft	96.97 ft	+ 33%	63.21 ft	- 13%	- 35%
Channel Depth (ft)	7.60 ft	10.99 ft	+ 45%	7.42 ft	- 2%	- 33%

Value-added Benefits

Developers in North Central Texas can effectively implement storm water management practices to address the impacts of new development and redevelopment, and to prevent and mitigate problems associated with urban storm water runoff. Within the limits of the study approach, the analyses of runoff quantity, floodplain impact, water quality, and streambank protection verified the benefits of iSWM design criteria at the watershed level for future conditions:

- Reduction in future runoff quantities to near existing conditions;
- Reduction in the increase of water surface elevations;
- Reduction in the increase of TSS loadings; and
- Reduction in the increase of erosion to channel depths and widths.

While the water quality analysis primarily focused on the simulated application of structural BMPs to reduce the pollutant loading to the stream, it can also be noted that water quality benefits are achieved through streambank protection. With bed and bank erosion as a primary source of TSS loadings within the North Central Texas region, a reduction in the amount of channel erosion, through streambank protection, will also result in a reduction in TSS loadings.

Summary of Big Fossil Creek Watershed Study

The benefits of iSWM may be extended beyond the individual site planning level to the watershed level when applied consistently throughout the development of a watershed. The Big Fossil Creek Watershed, located in the northwestern portion of the North Central Texas Council of Governments (NCTCOG) region, was selected for conceptual development utilizing the iSWM design criteria and watershed models (See Figure 1). The purpose was to test the potential impacts of iSWM application to the remaining undeveloped portions of Big Fossil Creek compared to development without ISWM practices.

The Big Fossil Creek Watershed covers an area of approximately 56 square miles and encompasses Big Fossil Creek, four un-named tributaries, and Whites Branch. Residential, commercial, and industrial development has primarily occurred in the lower portion of the watershed, leaving the undeveloped upper portion a prime location to simulate iSWM design criteria and verify watershed wide benefits.

The iSWM simulation within the Big Fossil Creek Watershed focused on the analysis of the iSWM design criteria in achieving the goals of flood control, water quality, and streambank protection for three watershed scenarios: existing watershed conditions, future conditions *without* the application of iSWM design criteria, and future conditions *with* the application of iSWM design criteria.

Flood Control Analysis – Runoff Quantity

The analysis of runoff quantity required the development of a hydrologic model. An existing conditions hydrologic model was first created, using the HEC-1 computer program, to reflect the current types of land use, soil conditions, and runoff parameters within the watershed. The Big Fossil Creek Watershed was divided into six basins, representing Big Fossil Creek, the four un-named tributaries, and Whites Branch. Each basin was comprised of varying numbers of sub-basins, ranging in area from 0.25 to 1.0 square miles. Figure 2 presents the computed existing conditions curve numbers for each sub-basin in the watershed. Curve numbers are a numerical description of the impermeability of the land in the watershed. This number varies from 0 (100% rainfall infiltration) to 100 (0% infiltration - i.e., pavement). This gives an indication for the potential for runoff.

The hydrologic model was then modified to reflect future developed conditions. Future developed conditions for the year 2025 were determined from land use projections provided by the NCTCOG and the City of Fort Worth. Increased impervious areas due to projected residential, commercial, and industrial growth are reflected in the increased curve numbers and somewhat reduced lag times computed throughout the watershed. Figure 3 presents the developed future curve numbers for each sub-basin in the watershed.

A second modified model was created to reflect the application of iSWM design criteria in the currently undeveloped areas of the upper portion of the watershed. Figure 4 highlights the undeveloped sub-basins selected for iSWM model application.

The hydrologic model was modified to reflect the iSWM design standard known as the ten percent rule. The ten percent rule recognizes the fact that a structural control providing detention has a “zone of influence” downstream where its effectiveness can be felt. Beyond this zone of influence the structural control becomes relatively insignificant compared to the runoff from the total drainage area.

Due to the limited budget and large number of sub-basins within the hydrologic model, a target range of acceptable peak flow reduction from 5 percent less than existing conditions peak flow to

25 percent less than existing conditions peak flow was assumed. This would allow for an average reduction in the 100-year peak flow to achieve the ten percent rule within the selected sub-basins. Table 1 presents the peak runoff values for the three watershed scenarios throughout the lower portion of the watershed, specifically from the stream crossing at Blue Mound Road to the base of the watershed, just upstream of State Highway 121. The application of iSWM design criteria in the upper portion of the watershed would almost maintain the runoff quantity of the existing conditions scenario. A detailed discussion of the hydrologic model development and modifications is presented in Appendix A.

Table 1. Summary of Conceptual Development Analysis – Runoff Quantity

Area of Big Fossil Creek Watershed (sq.mi.)	100 Year Peak Flow (cfs)					
	Existing Watershed Conditions	Future without iSWM Watershed Conditions	Percent Increase from Existing to Future	Future *with* iSWM Watershed Conditions	Percent Increase from Existing to Future *with* iSWM	Percent Increase from Future to Future *with* iSWM
16.64	16955	19259	13.6%	16963	0.0%	-11.9%
17.57	17355	19754	13.8%	17574	1.3%	-11.0%
18.18	17617	20030	13.7%	17967	2.0%	-10.3%
19.31	18603	21150	13.7%	19166	3.0%	-9.4%
19.98	18534	21100	13.8%	19368	4.5%	-8.2%
20.75	18832	21406	13.7%	19783	5.0%	-7.6%
21.76	19089	21683	13.6%	20296	6.3%	-6.4%
22.40	19176	21734	13.3%	20496	6.9%	-5.7%
28.63	24273	27668	14.0%	25724	6.0%	-7.0%
28.74	24132	27438	13.7%	25599	6.1%	-6.7%
31.06	25470	29011	13.9%	26737	5.0%	-7.8%
31.77	25308	28755	13.6%	26512	4.8%	-7.8%
32.32	23788	26648	12.0%	24731	4.0%	-7.2%
42.94	32280	36166	12.0%	33153	2.7%	-8.3%
43.44	31717	35501	11.9%	32668	3.0%	-8.0%
44.35	31756	35507	11.8%	32681	2.9%	-8.0%
49.84	33654	37495	11.4%	34175	1.5%	-8.9%
50.63	33805	37650	11.4%	34294	1.4%	-8.9%
51.17	33587	37420	11.4%	34119	1.6%	-8.8%
51.94	33715	37553	11.4%	34229	1.5%	-8.9%
52.57	33786	37628	11.4%	34313	1.6%	-8.8%
53.60	34016	37880	11.4%	34488	1.4%	-9.0%
54.31	33984	37800	11.2%	34443	1.4%	-8.9%
55.88	34204	38025	11.2%	34639	1.3%	-8.9%
56.63	33934	37678	11.0%	34398	1.4%	-8.7%

Flood Control Analysis - Floodplain Impact

The flood impact analysis applied the computed runoff quantities of the three watershed scenarios to a hydraulic model, previously created by the U.S. Army Corps of Engineers, Fort Worth District, along a defined stream reach, Interstate 35 to State Highway 121. This stream reach, located within the developed lower portion of the watershed, was selected because of identified flooding problems. As development occurs in the upper portion of the watershed, maintaining or lessening the impact of a flood event in the existing lower developed area is important.

Flood elevations were determined at multiple cross sections within the stream reach for the 100-year storm event. A detailed discussion of the hydraulic model and modifications is presented in Appendix B. Table 2 presents 100-year water surface elevations (WSEL) for the same three development scenarios as the hydrologic model discussed above at several locations within the stream reach. It can be seen that the flood elevation increase from existing conditions to future conditions without iSWM is greater than the increase from existing conditions to future conditions *with* iSWM.

Table 2. Summary of Conceptual Development Analysis – Flood Impact

Location	**100-Year Water Surface Elevation (ft)**				
	Existing Watershed Conditions	**Future without iSWM Watershed Conditions**	**Increase in Future WSEL from Existing Conditions**	**Future *with* iSWM Watershed Conditions**	**Increase in Future iSWM WSEL from Existing Conditions**
Flood Elevation (ft) Cross Section # 17130 Upstream of Hwy 183	512.66	513.98	1.32	512.81	0.15
Flood Elevation (ft) Cross Section # 35870/36000 Upstream of T&P RR	564.77	567.49	2.72	565.47	0.70
Flood Elevation (ft) Cross Section # 57920 Upstream of Western Ctr Blvd	605.84	607.84	2.00	606.47	0.63

The application of iSWM holds the flow elevation increase to an average increase of 0.27 feet throughout the reach, while uncontrolled development in just the currently undeveloped portion allows the 100-year flow elevation to increase by an average of 1.2 feet throughout the reach, with a maximum increase of 2.72 feet.

While this increase does not create problems in developed areas remote from the flood increases, in currently flooded areas would create increasingly dangerous flood depths and velocities for those homes currently flooded, a further reduction in property values, and would inundate several additional structures in the neighborhood. For example, Exhibits 1 and 2 show two neighborhoods where significant new portions of streetside flooding occurs. New flooding is indicated by the dark blue areas, while the light blue areas indicate existing 100-year floodplain limits. Actual planimetric structure footprint information was not assessed to verify actual structure locations. On a larger scale, figures 5 and 6 present the 100-year floodplain in the upper and lower portions of the watershed, respectively.

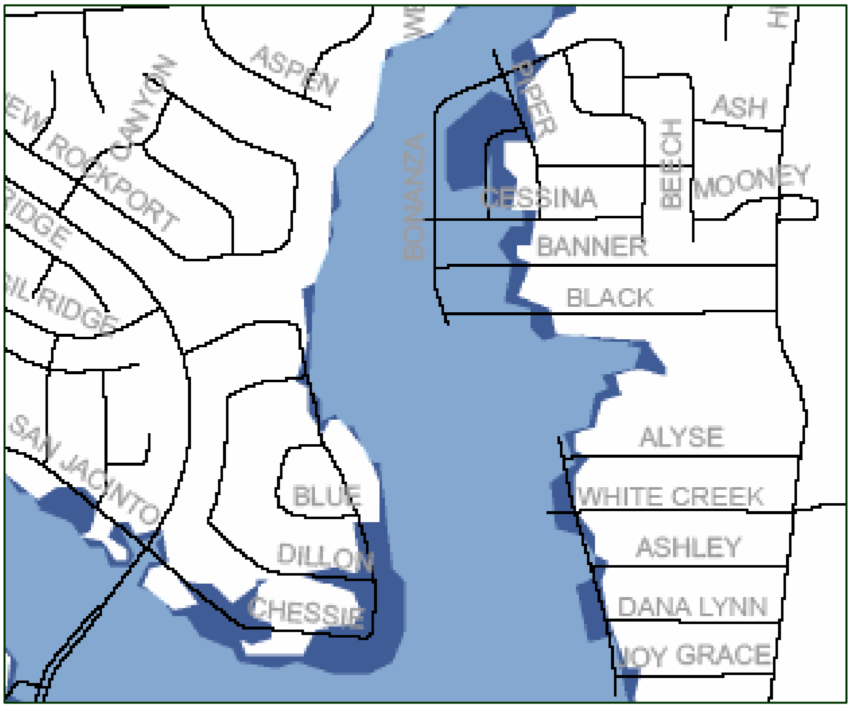


Exhibit 1. Neighborhood Flooding in Study Reach Example 1

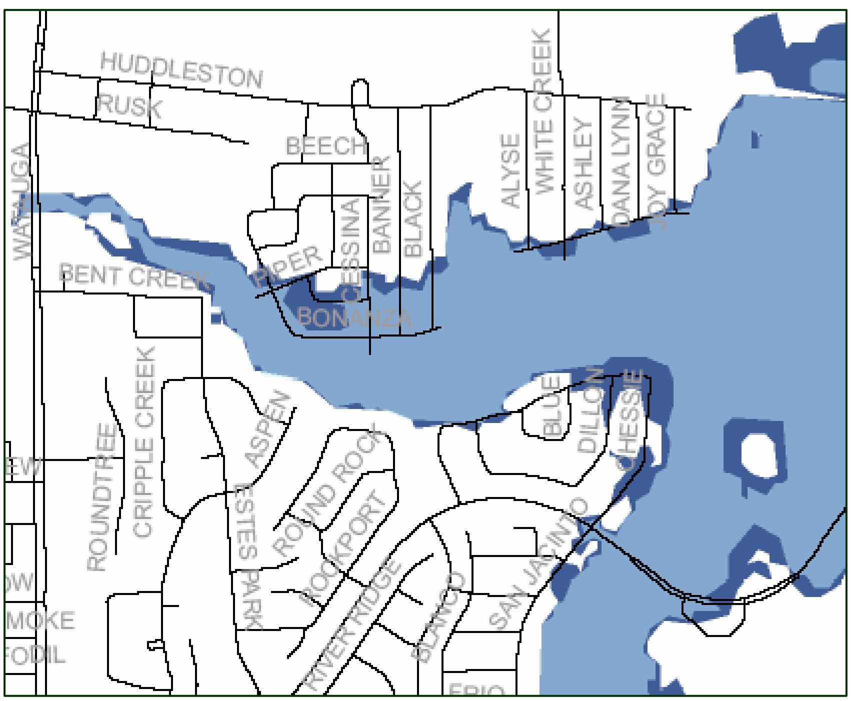


Exhibit 2. Neighborhood Flooding in Study Reach Example 2

Water Quality Analysis

The amount of total suspended solids (TSS) in a stream is a fair indicator of the overall water quality of the stream. But it is not without its problems especially in drier climates. Urban pollutants, such as oils and grease, attach themselves to the suspended solids and are transported downstream. Additionally, sediment in Texas streams is seen as a significant problem. Excess sediment in streams causes the following problems:

- Lost property or conveyance and adjacent structural damage;
- Safety concerns for crossing structures and steep or caving banks;
- Increased flooding due to channel siltation;
- Reservoir filling reducing storage capability;
- Water quality degradation;
- Ecological damage from turbid waters;
- Aesthetics & quality of life; and
- Property value preservation.

For the water quality analysis, TSS was selected as the indicator pollutant used to compare water quality impacts for the watershed scenarios. TSS pollutant loadings were computed for each sub-basin developed within the hydrologic model using a land use approach to estimate the annual and/or seasonal non-point source loads based upon the event mean concentrations (EMCs) and runoff volumes. Event mean concentrations were determined through a qualitative in-stream monitoring program completed by the NCTCOG. Table 3 presents the EMC values for TSS.

Table 3. Event Mean Concentrations, TSS (mg/l)

Type of Land Use	Season 1 (Sep – Oct)	Season 2 (Nov – Feb)	Season 3 (Mar – Jun)	Season 4 (Jul – Aug)
Commercial	41.5	37.5	46	37
Highway	62	142	134	142
Industrial	54	86	135	86
Open	118	332	118	332
Residential	90	73	116	73

“Open Space” has the highest TSS concentration per unit of runoff. But, when coupled with the much greater total volume of runoff per acre from more impervious areas, and the fact that other pollutants that attach to TSS are more highly concentrated in urbanized runoff, it is clear that urban development increases pollution to streams and channels.

Additionally, it can be surmised from data from the monitoring program that often the largest component of TSS loadings downstream are the result of bed and bank erosion within the channel itself (see discussion on stream erosion below). Thus the control of channel erosion through the channel protection criteria would also significantly improve the TSS loading reductions and associated stream water quality, though reduced channel erosion would not reduce other kinds of pollution.

Similar to the hydrologic and hydraulic model scenarios, water quality models were created for existing conditions, future conditions *without* iSWM, and future conditions *with* iSWM design criteria. In order to simulate the future conditions *with* iSWM scenario, a 70 percent reduction in TSS loadings was applied to each of the selected iSWM sub-basins, previously identified in the hydrologic model development. This application was done to reflect the design recommendations of the iSWM structural Best Management Practices (BMPs). The recommended water quality BMPs, if designed and installed properly and maintained, will remove 70-80 percent of the average annual TSS load in typical urban post-development runoff and a proportional removal of other pollutants.

While this assumption of 70-80 percent removal is true for sites with well designed and newly constructed controls, as we saw above, it may not be true for the whole watershed or for individual sub-basins. This is true, in part, because of bed and bank erosion, erosion along unprotected roadways, and general erosion in areas not protected by structural controls. Also, without proper maintenance, controls can lose effectiveness over time. No effort was made in this brief study to quantify these other sources of TSS and other pollutants.

Table 4 presents the TSS loadings determined for the entire watershed for the three watershed scenarios. A detailed discussion of the water quality model and TSS loading results for individual sub-basins is presented in Appendix C.

Table 4. Summary of Conceptual Development Analysis – Water Quality

Season	**TSS LOADING (lbs)**					
	Existing Watershed Conditions	**Future without iSWM Watershed Conditions**	**Percent Difference from Existing to Future**	**Future *with* iSWM Watershed Conditions**	**Percent Difference from Existing to Future *with* iSWM**	**Percent Difference from Future to Future *with* iSWM**
Sep- Oct	935,230	1,536,896	39%	1,311,525	24%	-17%
Nov – Feb	2,504,454	2,916,779	14%	2,515,762	0.4%	-16%
Mar – Jun	3,148,510	5,655,309	44%	4,777,553	29%	-18%
Jul – Aug	1,104,361	1,286,205	14%	1,109,387	0.4%	-16%
TOTAL ANNUAL LOADING	**7,692,556**	**11,395,189**	**32%**	**9,714,227**	**18%**	**-17%**

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The focus of the water quality analysis on TSS loadings reveals that urbanization does not necessarily increase the concentration of TSS from existing to future conditions. The EMC values determined for TSS within open space were significantly high, contributing to high TSS loadings for existing conditions. On a national level, the TSS concentrations for stabilized open space ranges between 150 and 250 mg/l.

Urbanization, however, does increase the volume of runoff, as well as the concentration of urban pollutants, such as oil and grease, attached to the suspended solids. It is the application of structural BMPs, which does reduce the TSS loading for future conditions *with iSWM* from future conditions without iSWM.

Streambank Protection Analysis

For the channel impact analysis, the computed runoff quantities from the three watershed scenarios were applied to a locally derived regression equation for computing channel erosion. Channel erosion and incision have both environmental and physical effects. As listed above, these effects range from undermining bridges, undermining pipeline crossings, lowering local ground water tables, filling reservoirs and detention ponds, loss of property (along with property value), and creating a safety problem with vertical cliffs to loss of wildlife habitats and biodiversity. The equation used in this study of Big Fossil Creek was derived in the technical paper *Erodibility of Urban Bedrock and Alluvial Channels, North Texas* (Allen, Peter M., et.al.). This technical paper identified and quantified the erosion processes and erosion potential of stream channel types specific to North Texas.

According to the technical paper, major erosion of urban stream channels in North Texas is found in smaller basins with contributing drainage areas of less than ten square miles. For these basins, four basic channel types have been identified based on bed and bank lithologies: alluvial banks and bottoms, alluvial banks and gravel bottoms, alluvial banks and rock bottoms, and rock banks and rock bottoms. Most channels, approximately 75 percent, have alluvial banks with gravel or rock bottoms. Channel slopes are steep and rock consists predominantly shale and limestone.

For the study of Big Fossil Creek, representative cross sections were identified in the stream reach from Interstate 35 to State Highway 121. From these cross sections it was possible to categorize the channel type as alluvial banks with rock bottom. For this specific channel type, a channel erosion equation derived in the technical paper was used to estimate the changes in channel shape due to the increased shear forces along channel side slopes and bottom width. A detailed discussion of the channel impact analysis is presented in Appendix D.

To illustrate the impacts of urban development on channel widths and depths, the equation is plotted against C factor. This exhibit was developed by calculating required peak flows for the channel size equation using the Rational Method. It is assumed that the initial undeveloped C Factor is 0.2. The exhibit illustrates what happens to a channel in terms of the ratio of stream width and depth compared to the “natural” width and depth for a C Factor of 0.20.

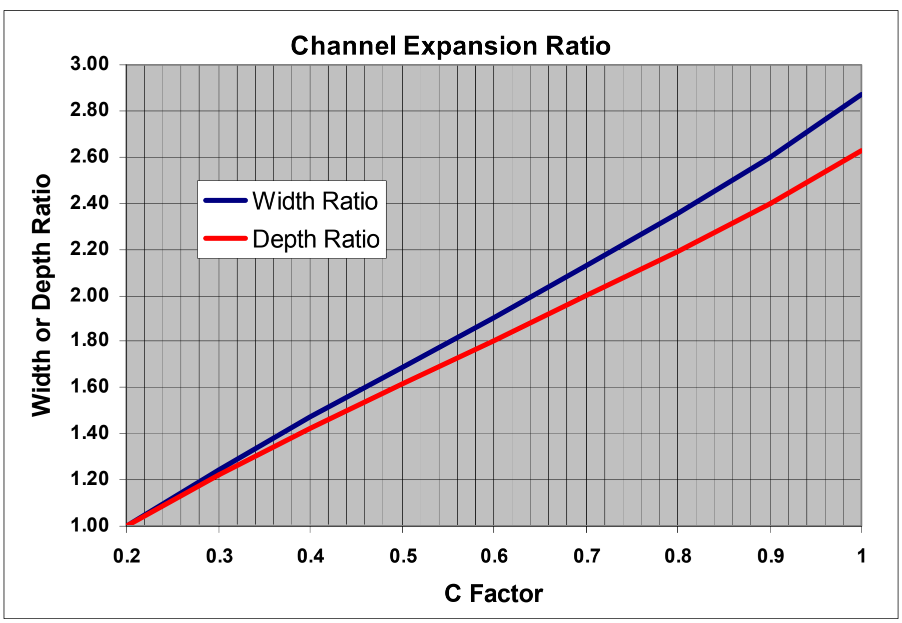


Exhibit 3. Channel Expansion Ratio versus Rational C Factor

When this equation is applied over the 9.5-mile study reach from Interstate 35 to State Highway 121, approximately 20,000,000 ft^3 (460 acre-feet) of sediment are anticipated to be removed from Big Fossil Creek under future conditions without the application of iSWM design criteria. When the watershed as a whole is considered with more than 85 miles of streams the total sediment load and potential for damage is enormous.

Table 5 presents the reduction in channel erosion between the future conditions without and *with* iSWM application for the specific cross section. Notice that the iSWM cross section is actually smaller than the existing condition. This indicates, within the margin of error of the equations, that the channel would have been less than its currently impacted shape had iSWM been used throughout the upstream area from the beginning. Exhibit 4 presents the specific channel cross sections for existing, future, and future *with* iSWM conditions.

Table 5. Summary of Conceptual Development Analysis – Streambank Protection

Type of Analysis	**Existing Conditions from HEC-2 Model**	**Future Conditions without iSWM**	**Percent Difference from Existing to Future**	**Future Conditions *with* iSWM**	**Percent Difference from Existing to Future *with* iSWM**	**Percent Difference from Future to Future *with* iSWM**
Channel Width (ft)	73.00	96.97	32.84%	63.21	-13.41%	-34.8%
Channel Depth (ft)	7.60	10.99	44.61%	7.42	-2.37%	-32.5%
Channel Area (ft^2)	429	824[1]	---	359[1]	---	---

[1]Trapezoidal channels with 2:1 side slopes were assumed for both of the future conditions scenarios.

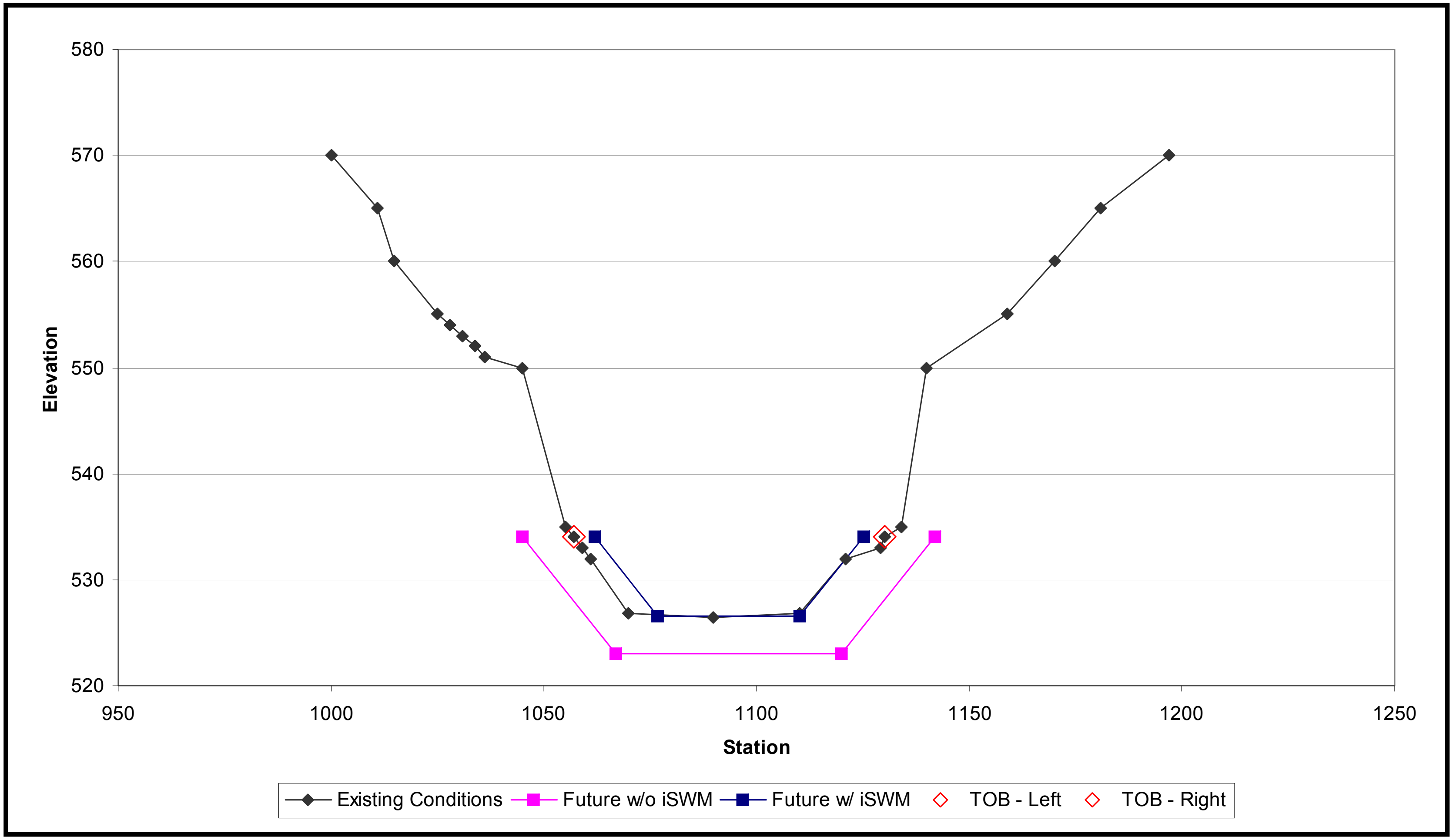


Exhibit 4. Computed Streambank Erosion on Sample Cross Section

Conclusion

Developers in North Central Texas can effectively implement storm water management practices to address the impacts of new development and redevelopment, and to prevent and to mitigate problems associated with urban storm water runoff. Within the limits of the study approach, the analyses of runoff quantity, floodplain impact, water quality, and streambank protection verified the benefits of iSWM design criteria at the watershed level for future conditions:

- Reduction in future runoff quantities to near existing conditions;
- Reduction in the increase of water surface elevations;
- Reduction in the increase of TSS loadings; and
- Reduction in the increase of erosion to channel depths and widths.

While the water quality analysis primarily focused on the simulated application of structural BMPs to reduce the pollutant loading to the stream, it can also be noted that water quality benefits are achieved through streambank protection. With bed and bank erosion as a primary source of TSS loadings within the North Central Texas region, a reduction in the amount of channel erosion, through streambank protection, will also result in a reduction in TSS loadings.

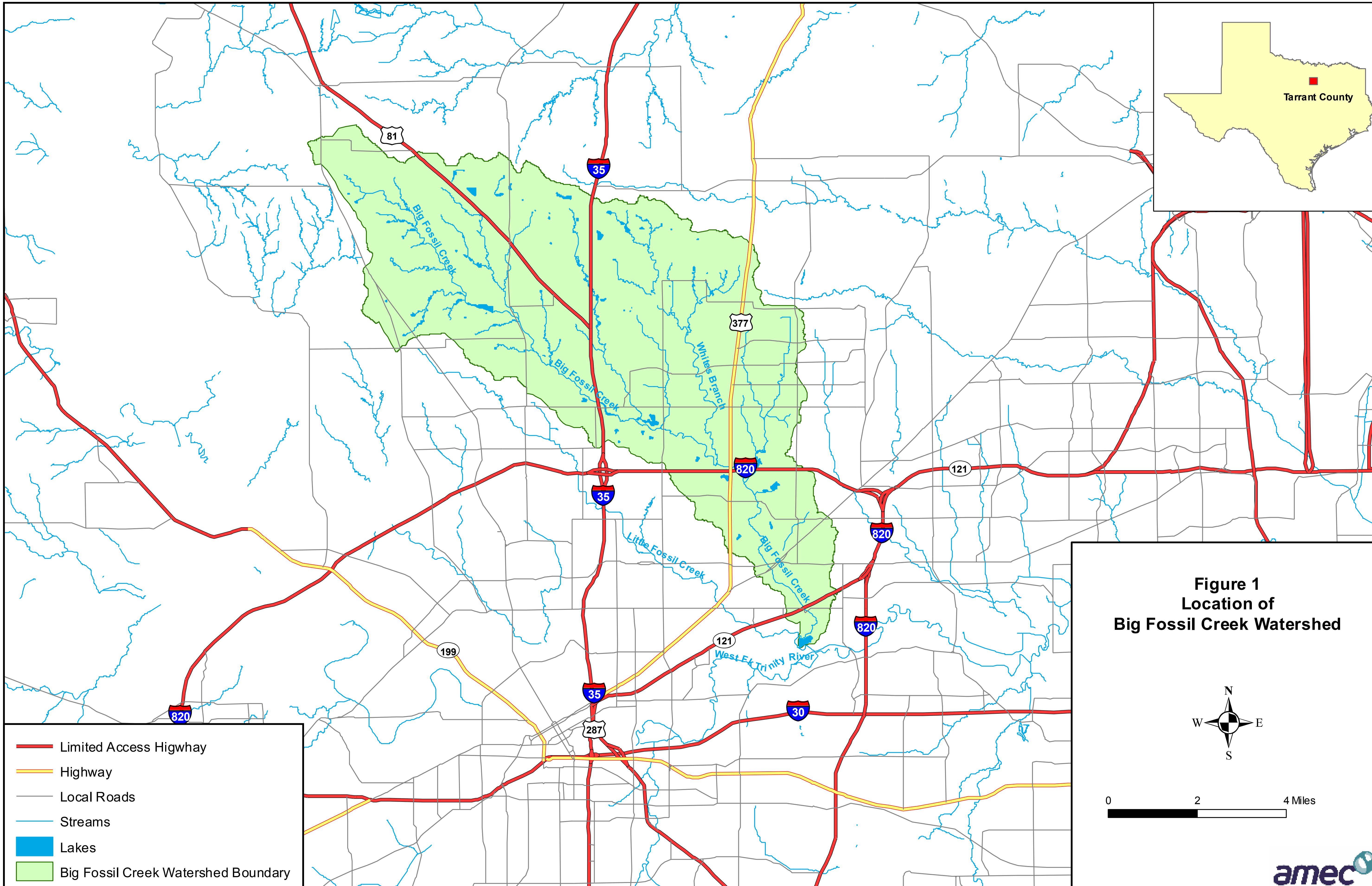
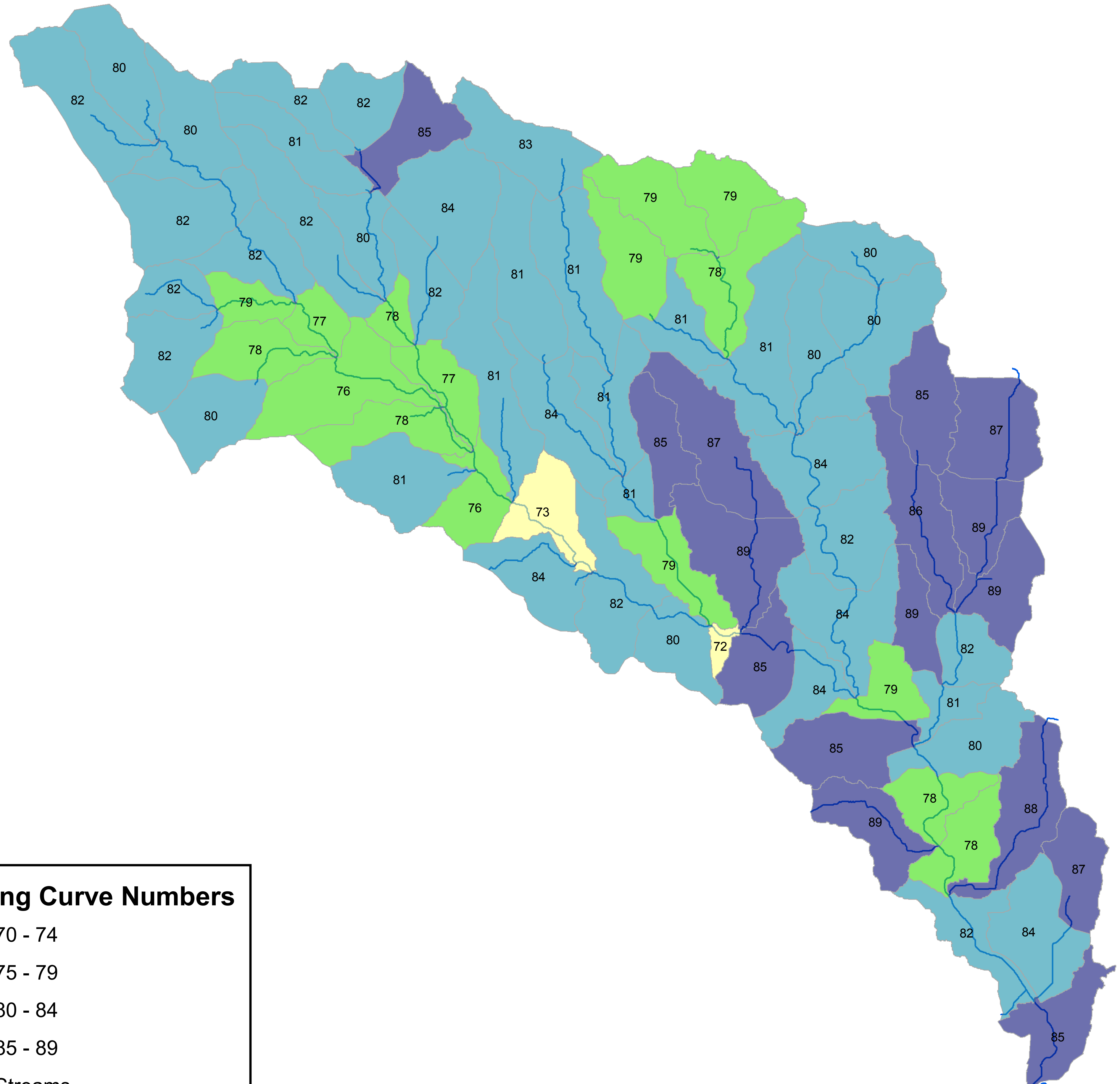


Figure 1
Location of
Big Fossil Creek Watershed



Existing Curve Numbers

- 70 - 74
- 75 - 79
- 80 - 84
- 85 - 89
- Streams

Figure 2
Existing Conditions Curve Numbers

N
W E
S

0 6,500 13,000 Feet

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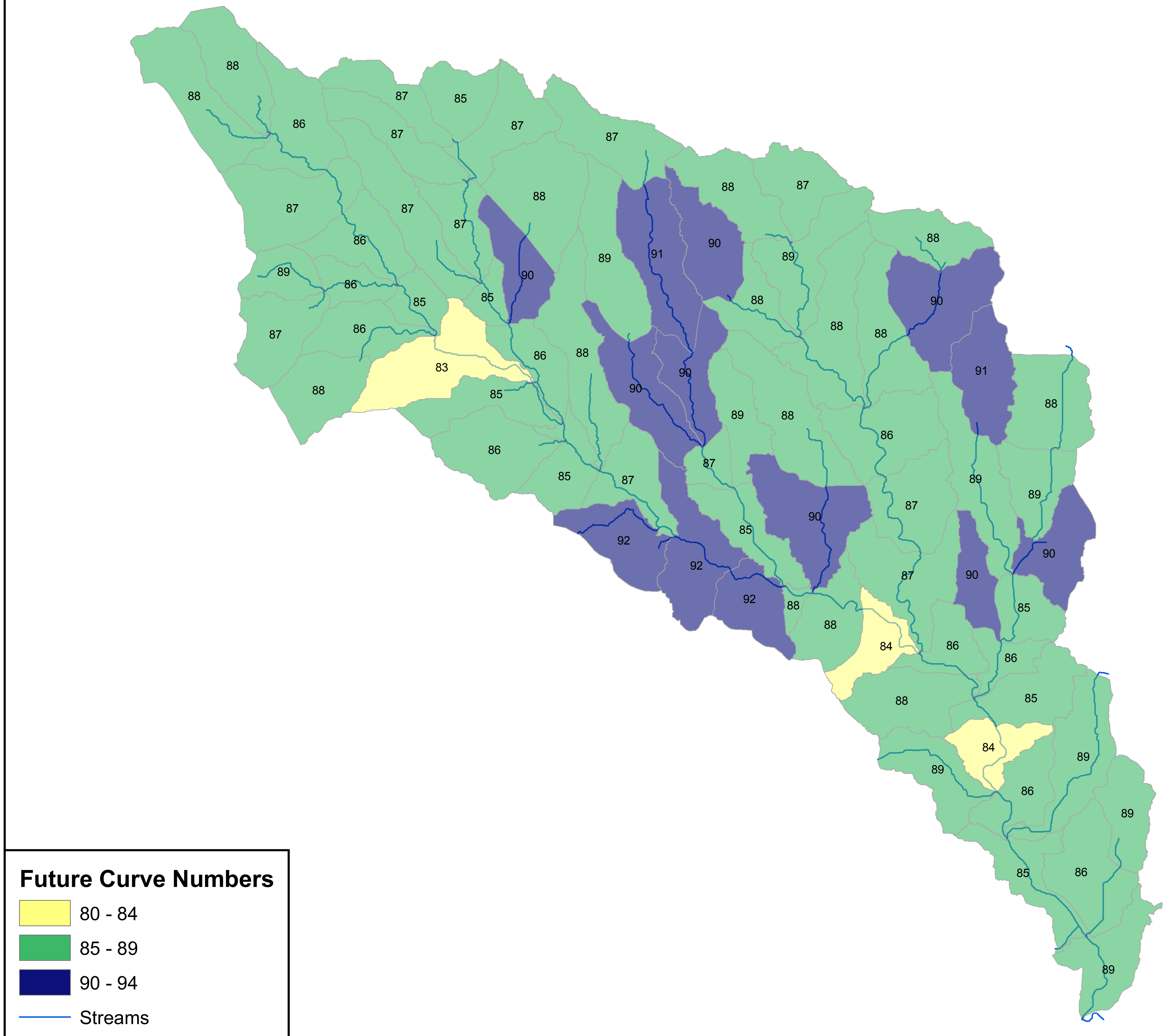
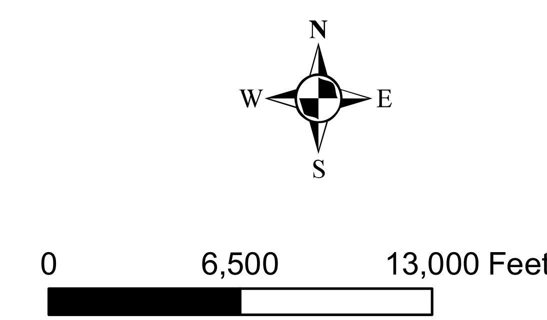


Figure 3
Future Conditions Curve Numbers



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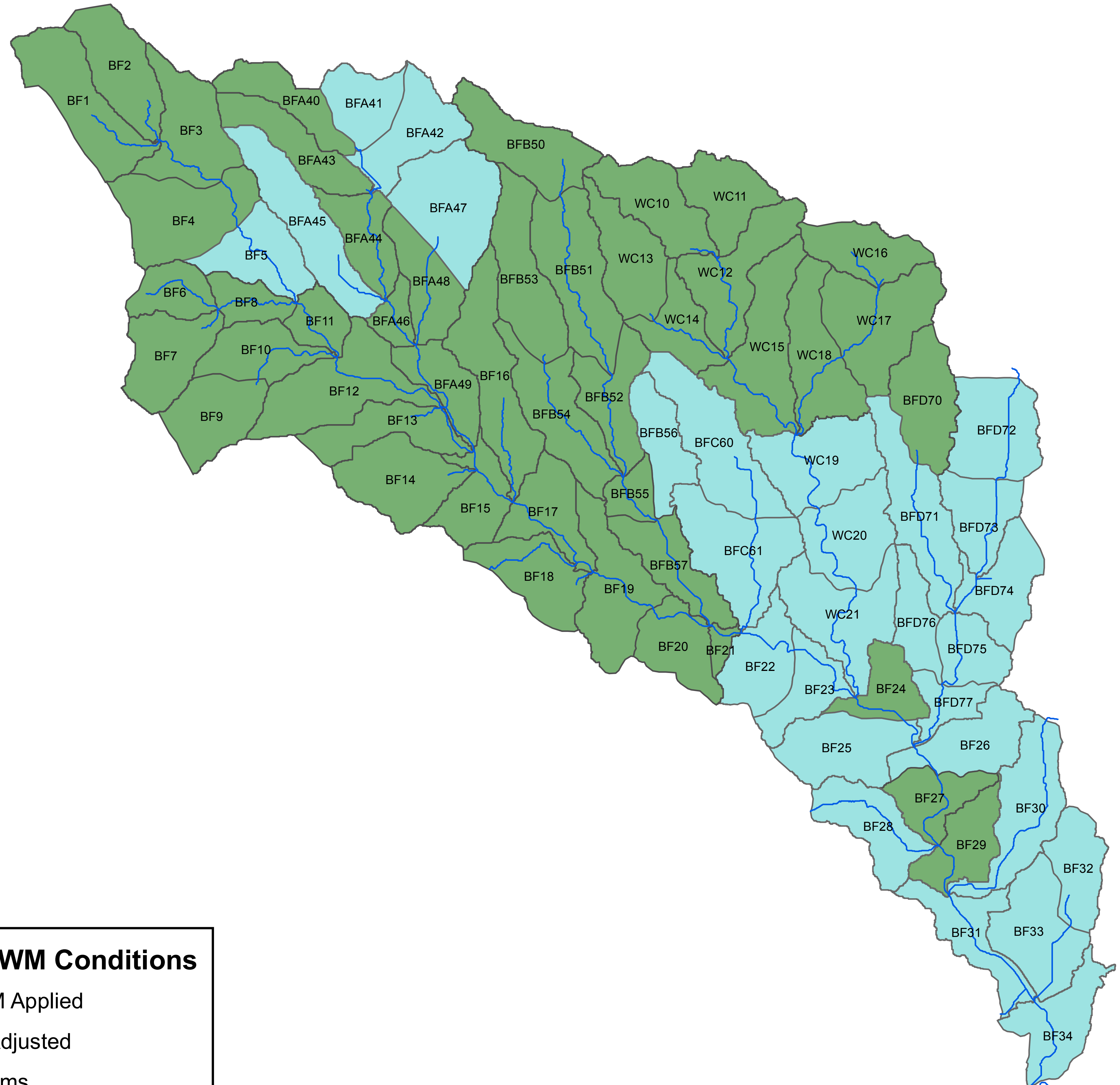

Future-iSWM Conditions

- iSWM Applied
- Not Adjusted
- Streams

Figure 4
Application of iSWM Design Methods for Future Conditions

0 6,500 13,000 Feet

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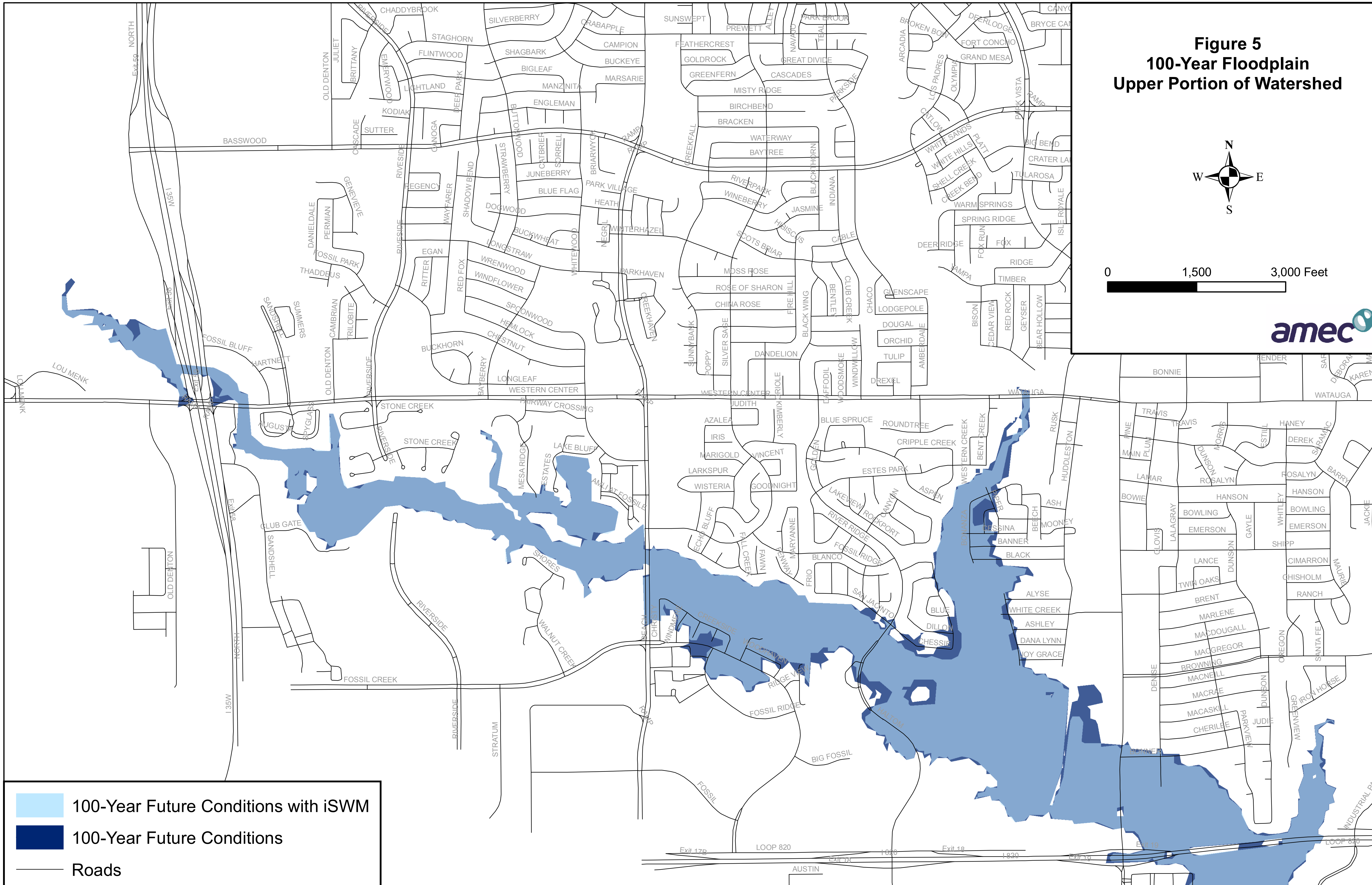
Figure 5
100-Year Floodplain
Upper Portion of Watershed



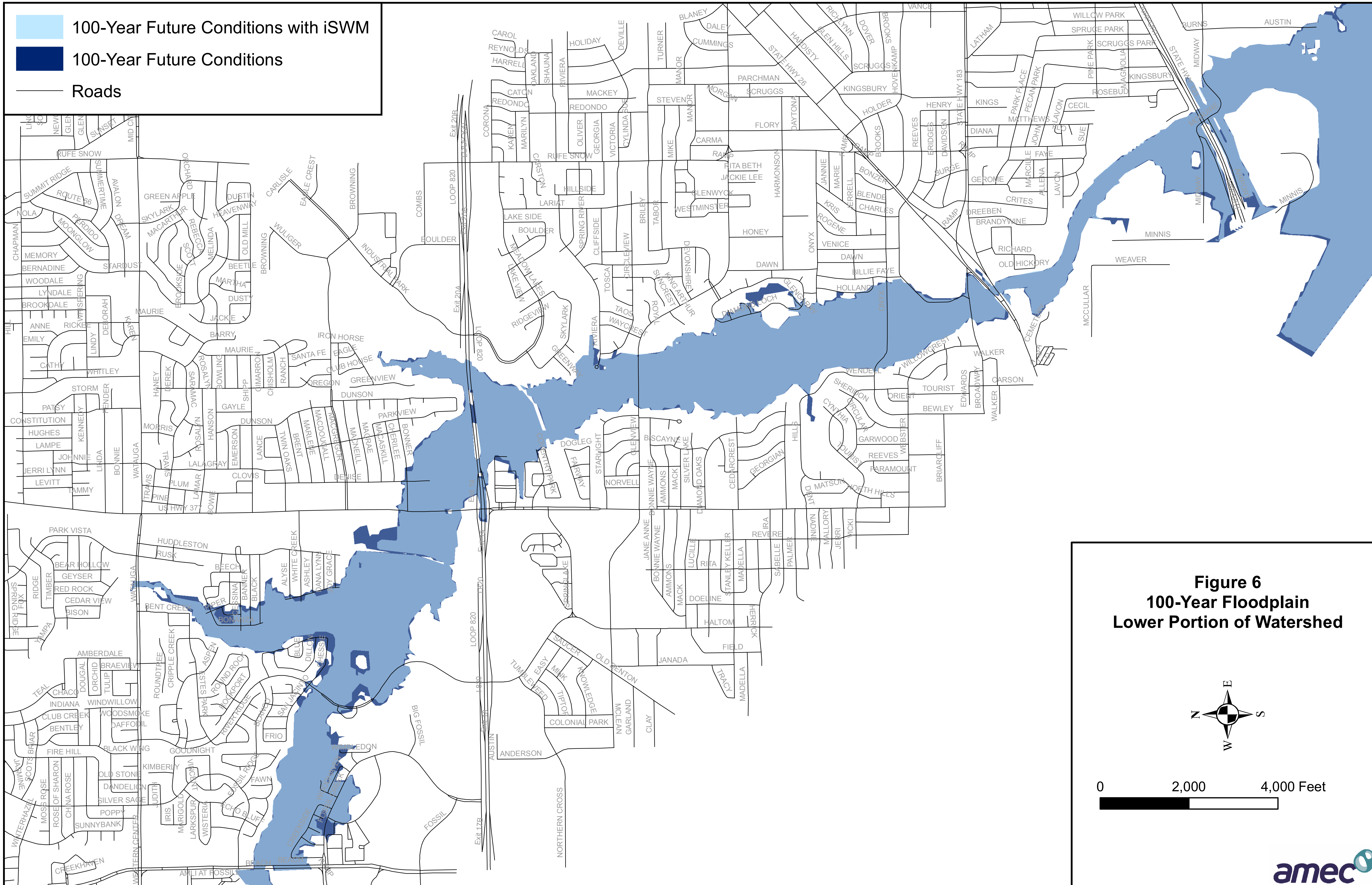


Figure 6
100-Year Floodplain
Lower Portion of Watershed

Appendix A – Runoff Quantity Analysis

A hydrologic model of Big Fossil Creek was created in order to estimate the flow rate of storm water runoff for the watershed. The model was developed from data including precipitation, basin characteristics, and types of soil and land uses. The model produced results that can be used to predict flows from a wide range of storm events.

The primary method of flow rate computation used was the Snyder's Unit Hydrograph. The HEC-1 Flood Hydrograph Package (USACE, 1990) computer model was used to facilitate the calculations. The following sections detail the procedures for developing the model, and present the results of the model.

Model Development
Input for the hydrologic model includes precipitation data, basin characteristic data (area, SCS runoff curve number, lagtime t_p and peaking coefficient C_p), and stream data (channel length, slope, roughness value, and/or storage-elevation/volume-discharge relationship).

Precipitation
A 24-hour balanced storm was used to simulate the design rainfall in the Big Fossil Creek hydrologic model. Table A-1 presents the 1-year and 100-year frequency rainfall depths for various durations used to develop the balanced storm for hydrologic modeling in the Big Fossil Creek Watershed.

Table A-1. Rainfall Depth-Duration-Frequency Data for Tarrant County

Frequency (years)	Rainfall Depths (inches)							
	5 min	15 min	1 hr	2 hr	3 hr	6 hr	12 hr	24 hr
1	0.44	0.83	1.36	1.62	1.77	2.04	2.28	2.64
100	0.92	2.00	3.84	4.84	5.43	6.54	7.68	9.12

Rainfall depths are presented in Appendix A of the *iSWM Design Manual for Development/Redevelopment.*

Unit Hydrograph
The HEC-1 model supports several unit hydrograph methods to transform rainfall excess into surface runoff. The method selected for this study was the Snyder's unit hydrograph method, which is the method used by the US Army Corps of Engineers, Fort Worth District, for the majority of hydrologic studies in the region. It is similar to the Soil Conservation Service (SCS) method, in that it considers the time distribution of the rainfall, the initial losses to interception and depression storage, and an infiltration rate that decreases during the course of a storm.

Areal Reduction and Computational Interval
The average rainfall depth over a watershed for a given frequency decreases with increasing drainage area. Areal reduction of point rainfall is necessary to reduce rainfall depths applied to a sub-basin by the HEC-1 model. The area of the Big Fossil Creek Watershed is over 56 square miles, therefore areal reduction of point rainfall was performed using the depth-area option in the HEC-1 model. A computation interval of 6 minutes (0.1 hrs) was chosen for the HEC-1 model of the Big Fossil Creek Watershed.

Drainage Boundary Delineation
Sub-basin boundaries in the Big Fossil Creek Watershed were automatically delineated using the digital mapping tool, ArcHydro, and two-foot contour information obtained from the NCTCOG. ArcHydro is an extension tool in the ArcMap digital mapping software program.
Adjustments were made to individual sub-basins in order to limit each sub-basin area to approximately one square mile. ArcHydro was used to estimate the longest flow path (L); to

estimate the length of the flow path from the centroid of sub-basin to the sub-basin's outlet (L_{ca}); and to extract elevations for both the highest and lowest points along the flow path. Table A-2 summarizes the hydraulic data used in the hydrologic analysis of Big Fossil Creek Watershed.

The Big Fossil Creek Watershed was divided into six basins, each comprised of varying numbers of sub-basins, for a total of 74 sub-basins within the watershed. Basins and sub-basin boundaries of the watershed are shown in Figure A-1. Sub-basins located in the Big Fossil Creek Watershed range in size from 150 acres to 770 acres, with an average size of approximately 500 acres. All sub-basin boundaries were utilized, without adjustment, for the existing and future conditions scenarios.

Table A-2. Hydrologic Data Summary

Sub-basin	Area (acres)	Area (sq.mi.)	Length of Longest Flow Path (L, ft)	Elevation Difference Along Longest Flow Path (ft)	Length of Flow Path from Sub-basin's Centroid to Outlet (L_{ca} ,ft)	Slope (ft/mi)
BF1	679.1	1.06	13864	94	6555	35.8
BF10	407.9	0.64	9657	107	5625	58.5
BF11	223.0	0.35	6641	52	3032	41.3
BF12	768.5	1.20	16653	122	7822	38.7
BF13	432.4	0.68	13548	116	8111	45.2
BF14	594.0	0.93	10556	112	6475	56.0
BF15	390.7	0.61	7595	85	2595	59.1
BF16	722.7	1.13	17346	129	8490	39.3
BF17	429.2	0.67	10814	89	5260	43.5
BF18	492.7	0.77	8283	83	3404	52.9
BF19	647.6	1.01	10804	109	3332	53.3
BF2	530.7	0.83	10961	70	6187	33.7
BF20	410.4	0.64	7549	88	3200	61.5
BF21	69.7	0.11	3897	87	1909	117.9
BF22	454.4	0.71	6000	100	2597	88.0
BF23	353.7	0.55	7937	113	4002	75.2
BF24	317.7	0.50	5405	80	3645	78.2
BF25	585.1	0.91	10979	122	5286	58.7
BF26	508.7	0.79	9242	106	3983	60.6
BF27	348.2	0.54	8035	88	4000	57.8
BF28	490.6	0.77	9663	107	4956	58.5
BF29	403.2	0.63	10381	128	4025	65.1
BF3	597.5	0.93	10529	72	4316	36.1
BF30	660.9	1.03	14958	116	8828	40.9
BF31	453.2	0.71	12034	113	5576	49.6

Table A-2. Hydrologic Data Summary

Sub-basin	Area (acres)	Area (sq.mi.)	Length of Longest Flow Path (L, ft)	Elevation Difference Along Longest Flow Path (ft)	Length of Flow Path from Sub-basin's Centroid to Outlet (L_{ca} ,ft)	Slope (ft/mi)
BF32	386.0	0.60	7618	68	3959	47.1
BF33	618.4	0.97	8946	122	4167	72.0
BF34	482.6	0.75	12039	66	4571	28.9
BF4	722.6	1.13	9301	96	4744	54.5
BF5	466.0	0.73	8735	86	4221	52.0
BF6	285.6	0.45	6868	72	3329	55.4
BF7	496.7	0.78	10529	72	4971	36.1
BF8	222.7	0.35	7189	70	3649	51.4
BF9	485.7	0.76	7306	58	3781	41.9
BFA40	356.7	0.56	10425	66	5424	33.4
BFA41	358.0	0.56	6536	128	3316	103.4
BFA42	484.7	0.76	9685	138	5241	75.2
BFA43	437.1	0.68	12515	81	6245	34.2
BFA44	372.2	0.58	9517	73	5029	40.5
BFA45	659.5	1.03	16563	104	8353	33.2
BFA46	152.3	0.24	5390	44	2313	43.1
BFA47	749.3	1.17	8680	120	4090	73.0
BFA48	405.1	0.63	9088	54	4370	31.4
BFA49	344.3	0.54	9534	78	4881	43.2
BFB50	577.2	0.90	11262	96	4911	45.0
BFB51	732.2	1.14	13153	144	7892	57.8
BFB52	438.2	0.68	10621	93	5524	46.2
BFB53	628.5	0.98	14069	151	6346	56.7
BFB54	621.8	0.97	13122	97	5911	39.0
BFB55	177.7	0.28	4819	58	2440	63.6
BFB56	376.8	0.59	10163	94	4843	48.8
BFB57	441.4	0.69	10377	88	4748	44.8
BFC60	735.6	1.15	13926	96	6037	36.4
BFC61	745.9	1.17	12760	71	6725	29.4
BFD70	526.9	0.82	8944	74	4080	43.7
BFD71	659.1	1.03	15938	136	7410	45.1
BFD72	622.5	0.97	6671	44	4038	34.8
BFD73	408.9	0.64	8623	76	4414	46.5
BFD74	468.0	0.73	6804	52	4284	40.4

Table A-2. Hydrologic Data Summary

Sub-basin	Area (acres)	Area (sq.mi.)	Length of Longest Flow Path (L, ft)	Elevation Difference Along Longest Flow Path (ft)	Length of Flow Path from Sub-basin's Centroid to Outlet (L_{ca} ,ft)	Slope (ft/mi)
BFD75	319.5	0.50	6284	94	3517	79.0
BFD76	303.6	0.47	9944	117	4621	62.1
BFD77	214.3	0.33	6915	135	3766	103.1
WC10	508.5	0.79	11653	120	5865	54.4
WC11	429.3	0.67	8250	96	4330	61.4
WC12	597.4	0.93	14325	176	6688	64.9
WC13	492.8	0.77	11682	123	4737	55.6
WC14	347.7	0.54	8187	104	3934	67.1
WC15	765.7	1.20	15374	192	6855	65.9
WC16	408.9	0.64	4899	42	2855	45.3
WC17	745.9	1.17	10329	96	3630	49.1
WC18	586.9	0.92	12134	203	5775	88.3
WC19	654.9	1.02	9028	94	4173	55.0
WC20	576.0	0.90	10785	119	4944	58.3
WC21	681.9	1.07	12210	97	7286	41.9

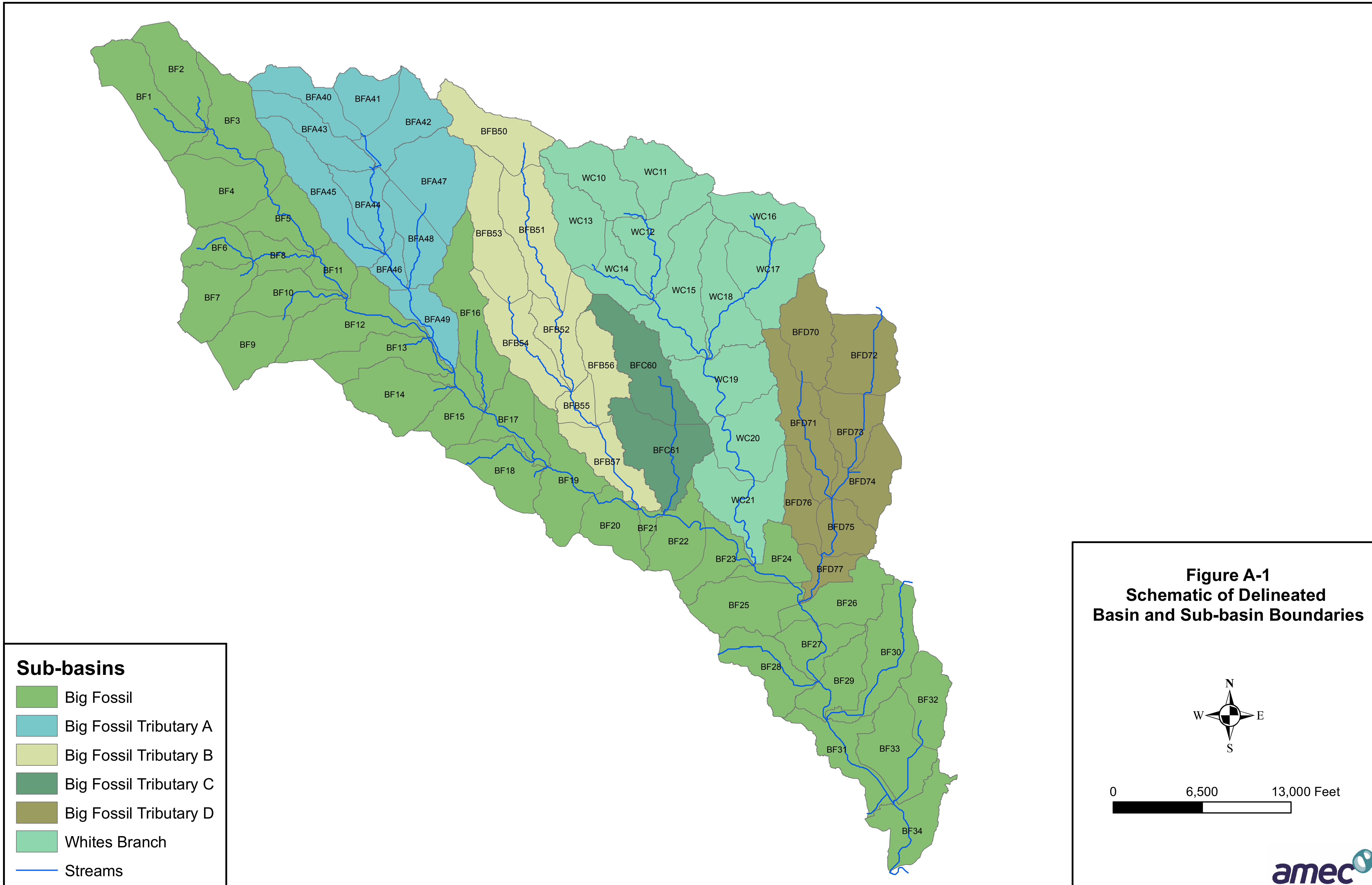


Figure A-1
Schematic of Delineated Basin and Sub-basin Boundaries

Soils Data
Soils information was provided by the NCTCOG in an ArcView shape file format. However the associated data table lacked the hydrological soil group definition. In order to populate this field, SURGO data were used to populate the hydrologic soil group. Soils delineation was utilized, without adjustment, for the existing and future conditions scenarios. The type of soil is a major factor in determining the amount of runoff that will occur during the event. Sandy soils will allow significant infiltration while rock formations tend to allow no infiltration. Soil types were matched to a specific hydrologic soil group (A, B, C, D) as used to compute curve numbers in the SCS method. The definition of each hydrologic soil group is given in Table A-3.

Table A-3. Definition of Hydrologic Soil Groups

Hydrologic Soil Group	Soil Group Characteristics
A	Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well-to-excessively-drained sands or gravels. These soils have a high rate of water transmission.
B	Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of transmission.
C	Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impeded downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
D	Soils have very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Curve Numbers
The SCS runoff curve number (CN) is an index developed to represent the combined hydrologic effect of soil type, land use, and antecedent soil moisture condition. Using this index to determine the amount of available storage (and subsequent precipitation excess) in a drainage basin is a standard hydrologic analysis technique developed by the SCS.

In watersheds that are delineated into numerous sub-basins, such as the Big Fossil Creek Watershed, GIS software is well suited for curve number estimation because it can manipulate the large amounts of spatial data (e.g., soil and land use coverage). Area-weighted curve numbers were determined for each sub-basin by combining the soil, land use, and sub-basin boundary maps in ArcView, through use of a script (i.e., program) developed specifically for curve number generation.

Since future land use designations were developed with the stipulation that runoff potential could not decrease from existing to future conditions, future curve numbers for each sub-basin will be equal to or greater than existing curve numbers.

Land Use
Land use was classified into 25 categories as designated by the *iSWM Design Manual for Development/Redevelopment*. Table A-4 presents these categories and the corresponding curve numbers. The curve numbers shown in Table A-4 are assumed to correspond to antecedent moisture condition II (AMC II).

Land use data for this study was provided by both the NCTCOG and the City of Fort Worth in ArcView shape file formats. Land use data for the year 2000 and 2003 was provided by the

NCTCOG. Future conditions land use data for the year 2025 was provided by the City of Fort Worth. For the existing conditions hydrologic model, the 2000 land use data was used. For future conditions hydrologic modeling, a combination of the NCTCOG and Fort Worth data was used. That is, the 2003 land use data was used to complete the portions of the watershed not included within the Fort Worth 2025 future land use information.

The 2000 and 2003 land use mapping from the NCTCOG defined land use through a numbered code field that ranged from 111 to 500. The future land use information from the City of Fort Worth defined land use through a descriptive code field. Table A-5 assigns a new land use code for both the NCTCOG and Fort Worth data that corresponds to the 25 land use categories designated by iSWM (See Table A-4).

Table A-4. Curve Number Look-Up Table

Cover Description	Land Use Code for Correlation	Curve Number by hydrological soil group				Cp Value
		A	B	C	D	
Cultivated Land w/o conservation treatment	1a	72	81	88	91	0.58
Cultivated Land w/ conservation treatment	1b	62	71	78	81	0.58
Pasture or Range land: Poor Condition	2a	68	79	86	89	0.58
Pasture or Range land: Good Condition	2b	39	61	74	80	0.58
Meadow: Good Condition	3	30	58	71	78	0.58
Wood or Forest Land: Thin Stand; Poor Cover	4a	45	66	77	83	0.58
Wood or Forest Land: Good Cover	4b	25	55	70	77	0.58
Open Space: Poor Condition (<50%)	5a	68	79	86	89	0.58
Open Space: Fair Condition (50% to 75%)	5b	49	69	79	84	0.58
Open Space: Good Condition (<75%)	5c	39	61	74	80	0.58
Impervious Areas	6	98	98	98	98	0.73
Streets and Roads: Paved excluding ROW	7a	98	98	98	98	0.73
Streets and Roads: Paved including ROW	7b	83	89	92	93	0.73
Streets and Roads: Gravel	7c	76	85	89	91	0.73
Streets and Roads: Dirt	7d	72	82	87	89	0.73
Urban Districts: Commercial and Business	8a	89	92	94	95	0.73
Urban Districts: Industrial	8b	81	88	91	93	0.73
Residential: 1/8 acre or less	9a	77	85	90	92	0.73
Residential: 1/4 acre	9b	61	75	83	87	0.66
Residential: 1/3 acre	9c	57	72	81	86	0.66
Residential: 1/2 acre	9d	54	70	80	85	0.66
Residential: 1 acre	9e	51	68	79	84	0.66
Residential: 2 acres	9f	46	65	77	82	0.66
Developing Urban Areas	10	77	86	91	94	0.66
Water	11	100	100	100	100	1.00

Curve Number data presented in the *iSWM Design Manual for Development/Redevelopment.*

Table A-5. Land Use Codes

NCTCOG Land Use Codes (2000 and 2003)	Corresponding Land Use Code		City of Ft. Worth Land Use Codes (2025)	Corresponding Land Use Code
111	9b		AG	1b
112	9a		NC	8b
113	9a		GC	8b
114	9f		HI	8a
121	8a		LI	8b
122	8a		IGC	8a
123	8a		MUGC	8b
131	8b		INFRA	7a
141	6		INST	9f
142	6		PRIPK	5c
143	3		PUBPK	5c
144	6		LDR	9e
171	5c		MDR	9d
171	5c		MH	9a
172	5b		RURAL	9f
173	5a		SF	9b
181	10		SUB	9b
300	5c			
308	7b			
500	11			

Lagtimes and Peaking Coefficient

Snyder's Unit Hydrograph method was used to calculate a runoff hydrograph for the development of the HEC-1 model of the Big Fossil Creek Watershed. This method requires specification of a lagtime (t_p) and peaking coefficient (C_p) for each sub-basin. The lagtime, specified in hours, is defined as the lag (time) between the center of mass of rainfall excess and the peak of the unit hydrograph.

The *iSWM Design Manual for Development/Redevelopment* describes the lagtime and peak flow (q_p) as:

$$t_p = C_t(L\ L_{ca})^{0.33}/S^{1/2}$$
$$q_p = C_p\ 640/t_p$$

The coefficient C_t is a regional coefficient for variations in slopes within the watershed. L is the river mileage from the sub-basin outlet to the upstream limits of the drainage area. L_{ca} is the river mileage from the outlet of the sub-basin into the center of gravity of the drainage area. S is the slope of the longest flow-path (ft/mi).

The coefficient C_p is the peaking coefficient, typically ranges from 0.3 to 1.2 with an average value of 0.8, and is related to the flood wave and storage coefficients of the watershed (See Table A-6). Larger values of C_p are generally associated with smaller values of C_t.

Table A-6. Typical Values of Cp

Typical Drainage Area Characteristics	Value of Cp
Undeveloped Area w/Storm Drains	
Flat Basin Slope <0.5%	0.55
Moderate Basin Slope 0.5% to 0.8%	*0.58*
Steep Basin Slope >0.8%	0.61
Moderately Developed Area	
Flat Basin Slope <0.5%	0.63
Moderate Basin Slope 0.5% to 0.8%	*0.66*
Steep Basin Slope >0.8%	0.69
Highly Developed/Commercial Area	
Flat Basin Slope <0.5%	0.7
Moderate Basin Slope 0.5% to 0.8%	*0.73*
Steep Basin Slope >0.8%	0.77

Cp values are presented in the *iSWM Design Manual for Development/Redevelopment.*

The lagtime for each sub-basins was calculated using the ArcHydro tools in the ArcMap environment. Automated utilities of Arc Hydro expedited the process of determining the parameters of the t_p equation: L , $L_{ca,}$ and slope.

After preliminary analysis, it was determined that the initial slope term in the equation for lagtime causes the lagtime to be too small for the size of watershed under consideration. In addition, the original format of Snyder's equation does not contain the slope (S) term. The addition of the slope S in the iSWM Design Manual refers to the U.S. Army Corps of Engineers Manual (EM 1112-2-1405). However, this reference states that in some instances, other measurable characteristics of basins maybe included in the original Snyder's methodology if regression analysis on the effect of the regressed parameter is developed for a region. Thus, the original format of Snyder's equation was used in this study.

For the determination of C_t, the iSWM Design Manual suggests that average values range from 0.4 to 2.3 with an average value of 1.1. Review of previous hydrologic modeling efforts of Big Fossil Creek by the U.S. Army Corps of Engineers indicated an average value of 0.45 was used for Little and Big Fossil Creek Watersheds. In order to estimate the C_t value, a regression formula was developed between the slope of each basin (ft/mile) and the C_t value used in the previous hydrologic model. The resulting equation:

$$C_t = (-0.0032 * \text{Slope}) + 0.5718$$

was used to estimate the C_t value, then it was increased uniformly by 0.1 for all sub-basins to adjust the t_p value.

In determining the C_p value, the iSWM Design Manual was used as a guide. Three levels of development; undeveloped, moderately developed, and highly developed categories were associated with different levels of land use. Due to the level of detailed delineated land use the median values of 0.58, 0.66, and 0.73 were assigned to C_p for the three respective levels of development. Subsequently, in the curve number lookup table (Table A-4) the appropriate C_p value was assigned to different categories of land use. C_p values within each sub-basin were area weighted and a composite C_p value was calculated for each sub-basin, Table A-7.

Future Conditions without iSWM
New development in the Big Fossil Creek Watershed is anticipated to be primarily residential or commercial. Changes in the curve numbers and subsequently C_p values were the only differences considered between the existing and the future condition models. No further adjustment in the C_t value was made for the future condition, see Table A-7.

Future Conditions with iSWM
A systematic procedure was used to simulate the effectiveness of the proposed best management practices in the iSWM manual. iSWM design criteria were applied only to selected sub-basins in the watershed; the undeveloped areas of the upper portion of the watershed. Sub-basins, for which the future curve number had the potential to increase more that 6 points from the existing conditions land use, were selected for iSWM application. Thus, iSWM design criteria was applied only to those sub-basins that were currently undeveloped but were anticipated to be developed in the future.

It was assumed that the iSWM design criteria would reduce the 100-year peak flow to a level approximately 15 percent below the existing condition's peak. Inferring that this will account for the ten-percent rule as presented in the *iSWM Design Manual for Development/Redevelopment.* Due to the large number of sub-basins within the hydrologic model, a target range of acceptable peak flow reduction from 5 percent less than existing conditions peak flow to 25 percent less than existing conditions peak flow was assumed. This would allow for an average reduction in the 100-year peak flow to achieve the ten-percent rule within the Big Fossil Creek Watershed.

The ten-percent rule recognizes the fact that a structural control providing detention has a "zone of influence" downstream where its effectiveness can be felt. Beyond this zone of influence the structural control becomes relatively insignificant compared to the runoff from the total drainage area. Based on studies and master planning results for a large number of sites, that zone of influence is considered to be the point where the drainage area controlled by the detention or storage facility comprises 10 percent of the total drainage area. For example, if the structural control drains 10 acres, the zone of influence ends at the point where the total drainage area is 100 acres or greater.

In order to decrease the iSWM selected sub-basins' outflow by target of 15 percent lower than the existing condition the C_t value was uniformly increased by 0.4. For those sub-basins that did not reach this target value, subsequent further modifications were made to the Ct values.

Table A-7 Hydrologic Variable Parameters for the Three Watershed Scenarios (iSWM application noted as Highlighted Sub-basins)

Sub-basin	Existing Conditions				Future Conditions *without* iSWM				Future Conditions *with* iSWM		
	CN	C_p	C_t	t_p	CN	C_p	C_t	t_p	CN	C_t	t_p
BF1	82	0.61	0.56	0.82	88	0.68	0.56	0.82	88	0.90	1.33
BF10	78	0.59	0.48	0.60	86	0.67	0.48	0.60	86	0.86	1.07
BF11	77	0.58	0.54	0.48	85	0.66	0.54	0.48	85	0.98	0.88
BF12	76	0.60	0.55	0.91	83	0.66	0.55	0.91	83	0.94	1.56
BF13	78	0.59	0.53	0.83	85	0.64	0.53	0.83	85	0.89	1.40
BF14	81	0.60	0.49	0.66	86	0.63	0.49	0.66	86	0.77	1.04
BF15	76	0.60	0.48	0.43	85	0.67	0.48	0.43	85	0.89	0.79
BF16	81	0.60	0.55	0.95	88	0.68	0.55	0.95	88	0.95	1.64
BF17	73	0.59	0.53	0.67	87	0.69	0.53	0.67	87	1.20	1.52
BF18	84	0.63	0.50	0.50	92	0.72	0.50	0.50	92	0.88	0.88
BF19	82	0.62	0.50	0.55	92	0.72	0.50	0.55	92	0.93	1.01
BF2	80	0.59	0.56	0.76	88	0.68	0.56	0.76	88	0.99	1.33
BF20	80	0.62	0.47	0.45	92	0.73	0.47	0.45	92	0.95	0.91
BF21	72	0.61	0.29	0.19	88	0.73	0.29	0.19	88	0.79	0.51
BF22	85	0.66	0.39	0.32	88	0.68	0.39	0.32	88	0.39	0.32
BF23	84	0.68	0.43	0.45	84	0.65	0.43	0.45	84	0.43	0.45
BF24	79	0.65	0.42	0.38	86	0.67	0.42	0.38	86	0.71	0.63
BF25	85	0.66	0.48	0.62	88	0.67	0.48	0.62	88	0.48	0.62
BF26	80	0.67	0.48	0.52	85	0.69	0.48	0.52	85	0.48	0.52
BF27	78	0.64	0.49	0.51	84	0.66	0.49	0.51	84	0.74	0.78
BF28	89	0.68	0.48	0.58	89	0.68	0.48	0.58	89	0.48	0.58
BF29	78	0.65	0.46	0.53	86	0.68	0.46	0.53	86	0.77	0.88
BF3	80	0.59	0.56	0.65	86	0.66	0.56	0.65	86	0.94	1.10
BF30	88	0.68	0.54	0.90	89	0.68	0.54	0.90	89	0.54	0.90
BF31	82	0.66	0.51	0.69	85	0.66	0.51	0.69	85	0.51	0.69
BF32	87	0.67	0.52	0.53	89	0.68	0.52	0.53	89	0.52	0.53
BF33	84	0.67	0.44	0.49	86	0.68	0.44	0.49	86	0.44	0.49
BF34	85	0.67	0.58	0.72	89	0.69	0.58	0.72	89	0.58	0.72
BF4	82	0.62	0.50	0.58	87	0.67	0.50	0.58	87	0.80	0.93
BF5	82	0.62	0.51	0.55	86	0.66	0.51	0.55	86	0.51	0.55
BF6	82	0.62	0.49	0.46	89	0.68	0.49	0.46	89	0.84	0.79
BF7	82	0.61	0.56	0.68	87	0.67	0.56	0.68	87	0.89	1.10
BF8	79	0.60	0.51	0.50	86	0.66	0.51	0.50	86	0.86	0.84

Table A-7 Hydrologic Variable Parameters for the Three Watershed Scenarios (iSWM application noted as Highlighted Sub-basins)

Sub-basin	Existing Conditions				Future Conditions *without* iSWM				Future Conditions *with* iSWM		
	CN	C_p	C_t	t_p	CN	C_p	C_t	t_p	CN	C_t	t_p
BF9	80	0.60	0.54	0.54	88	0.66	0.54	0.54	88	0.95	0.95
BFA40	82	0.62	0.56	0.71	87	0.67	0.56	0.71	87	0.86	1.09
BFA41	82	0.61	0.34	0.31	85	0.64	0.34	0.31	85	0.34	0.31
BFA42	85	0.64	0.43	0.53	87	0.65	0.43	0.53	87	0.43	0.53
BFA43	81	0.59	0.56	0.79	87	0.66	0.56	0.79	87	0.95	1.33
BFA44	80	0.58	0.54	0.65	87	0.66	0.54	0.65	87	0.94	1.13
BFA45	82	0.59	0.57	0.96	87	0.66	0.57	0.96	87	0.57	0.96
BFA46	78	0.59	0.53	0.41	85	0.66	0.53	0.41	85	0.93	0.72
BFA47	84	0.62	0.44	0.47	88	0.67	0.44	0.47	88	0.44	0.47
BFA48	82	0.62	0.57	0.64	90	0.70	0.57	0.64	90	0.98	1.10
BFA49	77	0.61	0.53	0.63	86	0.68	0.53	0.63	86	0.98	1.16
BFB50	83	0.64	0.53	0.66	87	0.67	0.53	0.66	87	0.78	0.98
BFB51	81	0.60	0.49	0.75	91	0.71	0.49	0.75	91	0.92	1.42
BFB52	81	0.60	0.52	0.67	90	0.70	0.52	0.67	90	0.97	1.24
BFB53	81	0.60	0.49	0.72	89	0.68	0.49	0.72	89	0.86	1.26
BFB54	84	0.62	0.55	0.77	90	0.69	0.55	0.77	90	0.90	1.26
BFB55	81	0.59	0.47	0.35	87	0.67	0.47	0.35	87	0.87	0.65
BFB56	85	0.63	0.52	0.62	89	0.69	0.52	0.62	89	0.52	0.62
BFB57	79	0.65	0.53	0.64	85	0.70	0.53	0.64	85	0.87	1.05
BFC60	87	0.66	0.56	0.80	88	0.68	0.56	0.80	88	0.56	0.80
BFC61	89	0.68	0.58	0.84	90	0.68	0.58	0.84	90	0.58	0.84
BFD70	85	0.63	0.53	0.58	91	0.69	0.53	0.58	91	0.87	0.95
BFD71	86	0.65	0.53	0.85	89	0.68	0.53	0.85	89	0.53	0.85
BFD72	87	0.67	0.56	0.55	88	0.67	0.56	0.55	88	0.56	0.55
BFD73	89	0.67	0.52	0.58	89	0.67	0.52	0.58	89	0.52	0.58
BFD74	89	0.68	0.54	0.55	90	0.69	0.54	0.55	90	0.54	0.55
BFD75	82	0.64	0.42	0.39	85	0.65	0.42	0.39	85	0.42	0.39
BFD76	89	0.67	0.47	0.56	90	0.67	0.47	0.56	90	0.47	0.56
BFD77	81	0.65	0.34	0.33	86	0.67	0.34	0.33	86	0.34	0.33
WC10	79	0.60	0.50	0.67	88	0.69	0.50	0.67	88	0.92	1.24
WC11	79	0.59	0.48	0.52	87	0.67	0.48	0.52	87	0.88	0.95
WC12	78	0.59	0.46	0.70	89	0.67	0.46	0.70	89	0.86	1.30
WC13	79	0.60	0.49	0.62	90	0.72	0.49	0.62	90	0.96	1.20

Table A-7 Hydrologic Variable Parameters for the Three Watershed Scenarios (iSWM application noted as Highlighted Sub-basins)

Sub-basin	Existing Conditions				Future Conditions *without* iSWM				Future Conditions *with* iSWM		
	CN	C_p	C_t	t_p	CN	C_p	C_t	t_p	CN	C_t	t_p
WC14	81	0.59	0.46	0.48	88	0.67	0.46	0.48	88	0.83	0.87
WC15	81	0.60	0.46	0.71	88	0.66	0.46	0.71	88	0.72	1.12
WC16	80	0.63	0.53	0.42	88	0.69	0.53	0.42	88	0.93	0.74
WC17	80	0.60	0.51	0.57	90	0.69	0.51	0.57	90	0.98	1.08
WC18	80	0.61	0.39	0.53	88	0.66	0.39	0.53	88	0.67	0.91
WC19	84	0.65	0.50	0.55	86	0.67	0.50	0.55	86	0.50	0.55
WC20	82	0.63	0.49	0.60	87	0.67	0.49	0.60	87	0.49	0.60
WC21	84	0.66	0.54	0.79	87	0.67	0.54	0.79	87	0.54	0.79

Hydrograph Routing

For those routing reaches where a HEC-2 model had been developed previously by the USACE Ft. Worth and could be located on associated USACE work maps, the Modified Puls Routing methodology was used for storage-routing analysis. Otherwise, Muskingum-Cunge channel routing method was used to represent the reach. An initial outflow equal to initial inflow was used for the initial condition. Table A-8 presents the storage routing reaches information obtained from previous HEC-2 models and used in HEC-1.

The Muskingum-Cunge channel routing method was used for stream reaches located at the upstream limits of the HEC-2 models or where no previous study was available. To perform Muskingum-Cunge routing, the HEC-1 model requires reach length, slope, Manning's n value, channel shape (trapezoidal, rectangular or circular), bottom width, and side slopes. Reach length, slope, Manning's n value and channel geometry parameters were determined using aerial photography and two-foot topographic maps. A sample cross section of flow within the routing reach was digitized in GIS and elevations along this cross section were extracted from the terrain data. HEC-1 requires an eight point cross section representing the routing reach, thus the extracted cross section was simplified to an eight point cross section representing the over banks and the channel geometry.

Table A-8. Routing Reaches developed from previous HEC-2 models

HEC-1 Routing Reach	HEC-2 Model	Downstream and Upstream Stations	SV and SQ cards	Reach Length (ft)	Avg Velocity (ft/s)	Time Steps
BFC61	K20BFC1	DS - 1150 US - 6940	SV 0 98 121 133 169 SQ 0 3550 4700 5200 6550	5790	8.0	2
WC14	K20WB	DS - 31190 US – 34950	SV 0 76 98 107 130 SQ 0 5150 6900 7600 9550	3760	4.0	3
WC15	K20WB	DS – 24700 US – 31190	SV 0 253 321 346 417 SQ 0 5950 8200 9100 11700	6490	5.5	3
WC19	K20WB	DS - 18140 US – 24700	SV 0 312 394 425 510 SQ 0 9100 12450 13850 17700	6560	8.5	2
WC20	K20WB	DS - 9850 US – 18140	SV 0 296 421 474 587 SQ 0 7200 10100 11500 14700	8290	8.0	3
WC21	K20WB	DS - 2310 US - 9850	SV 0 360 469 520 629 SQ 0 7200 10100 11500 14700	7540	8.0	3
BFD73	X20SINGH	DS - 13730 US – 19800	SV 0 95 118 133 160 SQ 0 3900 5200 5800 7200	6070	7.0	2
BFD74	X20SINGH	DS - 11230 US – 13660	SV 0 48 63 69 84 SQ 0 3900 5200 5800 7200	2430	7.0	1
BFD75	X20SINGH	DS - 6070 US – 10610	SV 0 141 183 200 240 SQ 0 5900 8000 8900 11200	4540	6.0	2
BFD77	X20SINGH	DS - 2310 US – 4850	SV 0 110 133 141 161 SQ 0 5900 8000 8900 11200	2540	7.0	1
BF4	K20BF0S3	DS - 94660 US – 96830	SV 0 41 59 67 83 SQ 0 4550 6150 6900 8600	2170	10.0	1
BF5	K20BF0S3	DS - 87800 US – 94660	SV 0 307 365 390 441 SQ 0 6100 8300 9250 11550	6860	7.0	3
BF11	K20BF0S3	DS - 83550 US – 87800	SV 0 160 209 228 273 SQ 0 5350 8700 9950 12800	4250	7.0	2
BF12	K20BF0S3	DS - 75720 US – 82700	SV 0 753 1031 1110 1293 SQ 0 10400 16200 18600 24450	6980	7.0	3
BFA49X	K20BF0S3	DS - 72900 US – 74650	SV 0 108 153 170 208 SQ 0 10400 16200 18600 24500	1750	7.0	1
BF15	K20BF0S3	DS - 71390 US – 71430	SV 0 2 3 4 5 SQ 0 10850 16700 19350 25350	1500	7.0	1
BF15	K20BF0S3	DS - 67930 US – 71390	SV 0 253 355 397 484 SQ 0 10350 16200 18800 24800	3460	7.0	1
BF17	K20BF0S3	DS - 60540 US – 66890	SV 0 297 472 543 688 SQ 0 10300 16250 18950 25150	6350	8.0	2

Table A-8. Routing Reaches developed from previous HEC-2 models

HEC-1 Routing Reach	HEC-2 Model	Downstream and Upstream Stations	SV and SQ cards	Reach Length (ft)	Avg Velocity (ft/s)	Time Steps
BF19	K20BF0S3	DS - 57110 US – 59260	SV 0 75 149 180 237 SQ 0 10300 16100 18800 25000	2150	7.5	1
BF20	K20BF0S3	DS - 51410 US – 54410	SV 0 128 202 231 290 SQ 0 14600 22000 25400 33450	3000	10.0	1
BF21	J20BFC	DS - 47270 US – 51410	SV 0 127 223 275 388 SQ 0 14590 22420 26620 34950	4140	10.0	1
BF22	J20BFC	DS - 42430 US – 47100	SV 0 307 422 526 708 SQ 0 13700 20040 23070 29360	4670	6.5	2
BF23	J20BFC	DS - 37340 US – 42020	SV 0 875 1661 2029 2912 SQ 0 20020 28590 32840 41080	4680	6.0	2
BF24	J20BFC	DS - 33400 US – 36970	SV 0 460 763 890 1155 SQ 0 19640 28020 31770 39400	3570	7.0	1
BF25	J20BFC	DS - 31080 US – 33180	SV 0 316 470 544 685 SQ 0 20670 29320 33570 41300	2100	6.0	1
BF26	J20BFC	DS - 29400 US – 30830	SV 0 130 176 197 232 SQ 0 20670 29320 33570 41300	1430	8.0	0
BF27	J20BFC	DS - 20430 US – 28300	SV 0 1299 1766 1978 2350 SQ 0 20300 29230 33820 42080	7870	7.0	3
B29	J20BFC	DS - 19110 US – 20230	SV 0 153 226 258 318 SQ 0 20300 29230 33820 42080	1120	6.0	1
BF31	J20BFC	DS - 10730 US – 18140	SV 0 727 974 1106 1411 SQ 0 19470 28620 33440 42000	7410	7.5	3
BF34	J20BFC	DS - 940 US – 10610	SV 0 2451 3188 3476 4059 SQ 0 26000 36750 41250 51750	9670	7.0	4
BF33	C20BF5	DS - 2170 US – 5470	SV 0 38 46 50 61 SQ 0 2100 2700 2900 3800	3300	7.0	1
BFB52	K20BFC2A	DS - 840 US – 6570	SV 0 138 174 189 223 SQ 0 2500 3400 3800 4750	5730	5.0	3
BFB54	K20BFC2	DS - 12600 US – 20920	SV 0 153 264 286 338 SQ 0 2000 2850 3150 3950	8320	6.5	4
BFB55	K20BFC2	DS - 8220 US – 11630	SV 0 128 164 179 214 SQ 0 5350 7500 8400 10600	3410	7.0	1
BFB57	K20BFC2	DS - 1140 US – 8130	SV 0 237 318 351 426 SQ 0 5350 7500 8400 10600	6990	7.0	3
WC12	K20WB1	DS - 1610 US – 4855	SV 0 69 87 94 115 SQ 0 3400 4550 5050 6550	3245	6.5	1
BFA49R	K20BFC4	DS - 1960 US – 4525	SV 0 120 152 167 203 SQ 0 7100 9900 11200 14200	2565	7.0	1

Table A-8. Routing Reaches developed from previous HEC-2 models

HEC-1 Routing Reach	HEC-2 Model	Downstream and Upstream Stations	SV and SQ cards	Reach Length (ft)	Avg Velocity (ft/s)	Time Steps
BFA46	K20BFC4	DS - 4650 US – 7900	SV 0 100 126 137 163 SQ 0 7150 9800 11000 13850	3250	6.5	1
BFA44	K20BFC4	DS - 9300 US – 16800	SV 0 170 217 236 286 SQ 0 3550 4900 5500 7050	7500	6.0	3
BFC48	K20BFC4A	DS - 730 US – 6960	SV 0 182 214 228 262 SQ 0 2600 3500 3900 4900	6230	7.0	2

Peak Discharge Determination

The HEC-1 models for the three scenarios: existing conditions, future conditions *without* iSWM application and future conditions *with* iSWM application were executed for the 1-year and 100-year storm events to determine the peak discharges. Table A-9 presents the peak discharges of each of the individual sub-basins for three scenarios for each storm event. For the future conditions *with* iSWM application 1-year event it was not feasible to simulate detention by adjusting the unit hydrograph parameters as was performed for the 100-year condition. Therefore the total volume beneath each selected sub-basins hydrograph for future condition 1-year event was taken and a constant rate flow hydrograph was developed in such a way that the sub-basin outlet would discharge the same volume over 24-hour period. Table A-9 also presents the future conditions *with* iSWM peak flows for selected sub-basins where the sub-basin C_t values were changed to accomplish reduction of future flows to produces peak flows approximately 15 percent lower than existing peak flows.

Table A-9. Comparison of Peak Discharges for the Three Watershed Scenarios (iSWM Application noted as Highlighted Sub-Basins)

Sub-basin	Flow 100-year (cfs)			Flow 1-year (cfs)			% Difference Existing Future-iSWM Peak Flow
	Existing	Future	Future iSWM	Existing	Future	Future iSWM	
BF1	1703	1985	1447	316	488	42	-15%
BF10	1139	1399	978	178	326	23	-14%
BF11	680	847	591	103	191	12	-13%
BF12	1586	1913	1341	212	373	36	-15%
BF13	978	1167	821	147	249	23	-16%
BF14	1636	1826	1383	294	413	33	-15%
BF15	1272	1607	1113	181	370	21	-13%
BF16	1581	1928	1336	275	464	44	-15%
BF17	991	1418	838	114	338	25	-15%
BF18	1753	2100	1498	379	633	37	-15%
BF19	2065	2591	1798	395	774	49	-13%
BF2	1299	1631	1134	219	401	33	-13%
BF20	1424	1853	1234	251	565	31	-13%
BF21	337	474	290	43	137	5	-14%
BF22	2142	2267	2267	509	613	613	
BF23	1405	1350	1350	307	292	292	
BF24	1239	1404	1068	217	337	18	-14%
BF25	1916	2000	2000	424	504	504	
BF26	1738	1905	1905	310	432	432	
BF27	1132	1263	970	182	274	18	-14%
BF28	1789	1789	1789	469	469	469	
BF29	1300	1506	1101	206	354	23	-15%
BF3	1603	1919	1375	273	438	33	-14%
BF30	1807	1827	1827	437	460	460	
BF31	1334	1392	1392	255	304	304	
BF32	1440	1482	1482	353	395	395	
BF33	2309	2404	2404	503	569	569	
BF34	1455	1558	1558	318	404	404	
BF4	2247	2540	1907	433	611	42	-15%
BF5	1495	1674	1674	286	390	390	
BF6	1021	1200	870	199	323	19	-15%
BF7	1386	1602	1180	262	380	29	-15%
BF8	721	846	620	121	201	13	-14%

Table A-9. Comparison of Peak Discharges for the Three Watershed Scenarios (iSWM Application noted as Highlighted Sub-Basins)

Sub-basin	Flow 100-year (cfs)			Flow 1-year (cfs)			% Difference Existing Future-iSWM Peak Flow
	Existing	Future	Future iSWM	Existing	Future	Future iSWM	
BF9	1486	1797	1271	257	456	30	-14%
BFA40	998	1121	854	189	268	21	-14%
BFA41	1579	1709	1709	325	408	408	
BFA42	1718	1784	1784	383	436	436	
BFA43	1055	1260	894	187	295	26	-15%
BFA44	989	1214	850	168	289	22	-14%
BFA45	1429	1689	1689	259	388	388	
BFA46	536	646	462	87	150	8	-14%
BFA47	2688	2999	2999	575	770	770	
BFA48	1183	1436	1019	223	391	28	-14%
BFA49	935	1164	791	137	269	19	-15%
BFB50	1719	1886	1470	341	450	34	-14%
BFB51	1857	2399	1594	329	669	52	-14%
BFB52	1185	1498	1023	213	405	30	-14%
BFB53	1655	2012	1405	295	521	41	-15%
BFB54	1669	1942	1424	341	517	42	-15%
BFB55	702	834	595	133	213	11	-15%
BFB56	1206	1343	1343	265	354	354	
BFB57	1286	1488	1092	211	329	24	-15%
BFC60	2103	2169	2169	493	531	531	
BFC61	2176	2198	2198	552	581	581	
BFD70	1721	1958	1459	380	556	38	-15%
BFD71	1777	1908	1908	395	484	484	
BFD72	2267	2293	2293	552	582	582	
BFD73	1475	1475	1475	386	386	386	
BFD74	1755	1795	1795	464	495	495	
BFD75	1277	1348	1348	260	314	314	
BFD76	1108	1119	1119	291	306	306	
BFD77	920	1004	1004	180	248	248	
WC10	1330	1690	1148	217	420	31	-14%
WC11	1310	1621	1120	216	399	25	-15%
WC12	1495	1908	1287	229	492	39	-14%
WC13	1388	1823	1207	227	502	34	-13%
WC14	1133	1370	965	212	350	22	-15%

Table A-9. Comparison of Peak Discharges for the Three Watershed Scenarios (iSWM Application noted as Highlighted Sub-Basins)

Sub-basin	Flow 100-year (cfs)			Flow 1-year (cfs)			% Difference Existing Future-iSWM Peak Flow
	Existing	Future	Future iSWM	Existing	Future	Future iSWM	
WC15	2045	2386	1787	366	593	47	-13%
WC16	1511	1801	1297	272	474	26	-14%
WC17	2205	2800	1894	384	767	51	-14%
WC18	1850	2200	1570	322	561	36	-15%
WC19	2243	2356	2356	476	549	549	
WC20	1788	1989	1989	346	482	482	
WC21	1903	1998	1998	393	469	469	

Hydrologic Model Results

The hydrologic model of the Big Fossil Creek Watershed provides peak discharge estimates at numerous locations in the watershed. Table A-9 presents a comparison of the peak discharges of the three proposed scenarios for the two flood events, 1-year and 100-year. The tabulated values are the individual sub-basins' hydrograph peaks. In order to analyze the aggregate effect of best management practices suggested in iSWM manual, a single location was chosen for comparison of peak flow from the three scenarios. The chosen comparison location was just upstream of State Highway 121, the most downstream location of Big Fossil Creek before receiving flow from Little Fossil Creek.

Runoff from the existing conditions scenario (34,204 cfs) as compared to the future conditions *without* iSWM scenario (38,026 cfs) increases by 11.2 percent while the increase to the future conditions *with* iSWM scenario (34,634 cfs) is 1.3 percent. The application of iSWM design criteria in the upper portion of the watershed would almost maintain the runoff quantity of the existing conditions scenario.

For the future conditions with iSWM, the assumption was made that application of best management practices recommended through the iSWM manual at a sub-basin level could potentially reduce peak flow by 15 percent, thus reducing the effect downstream. This assumption was put to test through simulation. Sub-basins for which future curve number had the potential to increase more that 6 points were selected. The time to peak of their corresponding hydrograph were altered in such a way that the peak discharge would be reduced by approximately 15 percent relative to the existing 100-year peak flow. The result of this analysis indicated that the discharge at the junction just upstream of State Highway 121 would equal 34634 cfs. This is equivalent to a 1.26 percent increase in discharge relative to the existing condition.

Although the hydrologic model developed and analyzed for this study was used for comparative runoff quantity purposes only, it is encouraging to note the similarities with an existing USACE Ft. Worth hydrologic model of the Big Fossil Creek Watershed. This previous hydrologic model, SWFHYD, Southwest Fort Worth Hydrology (USACE 1986), was developed for a drainage area of 55.0 square miles. For existing conditions the SWFHYD model produces a flow of 33,813 cfs. For future conditions, or as it is titled in the SWFHYD model "projected urbanization (fully developed) runoff condition", flow is predicted as 37,228 cfs.

The HEC-1 model developed for the Big Fossil Creek Watershed Study was developed for a drainage area of 55.88 square miles. For future conditions the HEC-1 model produces a flow of 34,204 cfs. For future conditions without iSWM design criteria, flow is calculated at 38,026 cfs. The HEC-1 model predicts a 11.2 percent increase in existing versus future flow, whereas SWFHYD predicts an increase of 10.1 percent.

Appendix B – Flood Impact Analysis

The flood impact analysis applied the computed runoff quantities of the three watershed scenarios to a HEC-2 (USACE, 1989) hydraulic model along a defined stream reach between Interstate 35 and State Highway 121. The hydraulic model for this study was developed through the combination of several hydraulic models previously created by the U.S. Army Corps of Engineers, Fort Worth District (USACE, Ft. Worth).

Two USACE Ft. Worth HEC-2 models, identified as J20BFC and K20BFOS3, previously modeled the selected stream reach. The appropriate cross sections from upstream of Interstate Highway 35 to downstream of State Highway 121, including bridge and culvert information, were extracted from the USACE models and combined into a single HEC-2 model. The flows (identified as QT cards) were updated to reflect the three watershed scenarios: existing conditions, future conditions *without* iSWM, and future conditions *with* iSWM, for the 1- and 100-year storm events (see Table B-1).

The combined HEC-2 model was executed to produce the water surface elevations (see Table B-2). The centerline of the study reach of Big Fossil Creek was calibrated by positioning the HEC-2 stations over the digital stream information. The calculated water surface elevations were digitally plotted using a floodplain routine scripted in Visual Basic in the ArcMap environment. Figures 5 and 6, presented in the Summary Portion of this Study, display the floodplains graphically for comparative purposes.

Table B-1. Updated Flow Change Points within HEC-2 Model.

HEC-2 Station	HEC-1 Sub-Basin	Flow 100-year (cfs)			Flow 1-year (cfs)		
		Existing	Future	Future-iSWM	Existing	Future	Future-iSWM
60540	BF18C	18832	21406	19783	2769	4049	1906
57110	BF19C	19089	21683	20296	2821	4109	1948
51410	BF20D	24273	27668	25724	3631	5446	2275
49300	BF21D	25470	29011	26737	3908	5793	2552
47220	BF22C	25308	28753	26512	3916	5798	2564
38200	BF23D	32280	36169	33153	5351	8354	3416
35870	BF24C	31717	35503	32668	5293	8231	3375
31080	BF25D	33654	37496	34175	5738	8744	4924
28980	BF26C	33805	37652	34294	5759	8765	5034
22920	BF28C	33715	37554	34229	5677	8547	4836
20850	BF30C	34016	37881	34488	5727	8598	4992
16340	BF31D	34204	38026	34639	5742	8576	5054
3180	BF31D	34204	38026	34639	5742	8576	5054

Table B-2. Water Surface Elevation for Applied Scenarios

HEC-2 Station	Flood Elevation for 100-Year Event (ft)			Flood Elevation for 1-Year Event (ft)		
	Existing	Future	Future-iSWM	Existing	Future	Future-iSWM
940	498.75	499.3	498.82	488.6	491.33	487.84
3180	499.70	500.24	499.77	489.76	492.49	489.00
6790	501.55	502.08	501.61	492.76	495.06	492.13
8510	503.48	504.13	503.56	494.01	496.24	493.38
9950	504.99	505.69	505.07	494.57	497.07	493.88
10000	505.00	505.73	505.08	494.41	496.83	493.74
10020	505.15	505.88	505.24	494.51	496.96	493.82
10100	505.49	506.17	505.57	495.04	497.79	494.28
10340	505.75	506.44	505.83	495.19	497.99	494.42
10390	505.44	506.07	505.51	495.19	497.97	494.43
10430	505.68	506.36	505.76	495.21	498.00	494.44
10520	505.90	506.67	505.99	495.22	498.01	494.45
10610	505.91	506.65	505.99	495.23	498.02	494.46
10730	505.97	506.72	506.06	495.23	498.03	494.46
10780	506.08	506.91	506.17	495.24	498.03	494.46
11180	506.51	507.36	506.61	495.28	498.09	494.50.
11910	506.67	507.53	506.77	495.33	498.15	494.55
12380	506.70	507.52	506.79	495.37	498.20	494.58
13120	507.02	507.87	507.12	495.44	498.29	494.65
14120	507.60	508.49	507.70	495.60	498.46	494.81
14780	508.06	508.97	508.16	495.76	498.62	494.96
15660	508.90	509.87	509.02	496.14	498.95	495.36
16000	509.48	510.43	509.59	496.81	499.53	496.08
16340	510.17	511.15	510.29	497.43	500.04	496.74
16680	510.32	511.26	510.43	497.91	500.39	497.24
16920	510.68	511.62	510.79	498.32	500.72	497.68
16960	511.04	512.02	511.16	498.53	500.91	497.88
17000	511.63	512.77	511.77	498.73	501.04	498.11
17030	511.01	511.98	511.12	498.67	500.97	498.04
17080	511.58	512.62	511.70	498.92	501.22	498.29
17130	512.66	513.98	512.81	499.21	501.47	498.59
17700	513.62	514.90	513.77	501.51	503.61	500.91
17750	513.63	514.82	513.66	501.80	503.91	501.19
17790	513.92	514.82	514.01	502.04	504.25	501.40
17840	515.08	515.63	515.15	502.31	504.55	501.65

Table B-2. Water Surface Elevation for Applied Scenarios

HEC-2 Station	Flood Elevation for 100-Year Event (ft)			Flood Elevation for 1-Year Event (ft)		
	Existing	Future	Future-iSWM	Existing	Future	Future-iSWM
18140	516.71	517.28	516.78	503.5	505.86	502.80
19110	519.00	519.65	519.08	507.22	509.68	506.44
19920	520.44	521.06	520.52	509.54	511.97	508.75
19970	520.45	521.07	520.53	510.00	512.56	509.18
20020	520.49	521.11	520.57	510.04	512.60	509.22
20060	520.51	521.13	520.59	510.07	512.64	509.24
20120	520.65	521.27	520.73	510.10	512.67	509.27
20160	520.65	521.27	520.73	511.94	513.27	510.85
20230	520.69	521.31	520.77	511.96	513.29	510.87
20430	520.71	521.33	520.79	512.06	513.44	510.98
20610	520.83	521.45	520.91	512.14	513.57	511.05
20850	521.14	521.76	521.21	512.32	513.87	511.24
22920	524.03	524.60	524.10	516.39	518.76	515.42
24720	527.70	528.18	527.76	520.95	523.00	520.05
24750	527.91	528.40	527.98	520.40	522.77	520.12
24780	527.91	528.39	527.97	521.83	523.34	521.48
25750	529.61	530.08	529.67	522.84	524.64	522.37
25790	529.68	530.15	529.74	522.98	524.83	522.49
25800	529.71	530.19	529.77	522.90	524.13	522.44
25810	529.77	530.24	529.83	522.87	524.06	522.34
25820	529.83	530.28	529.89	523.46	526.26	522.76
26450	530.68	531.14	530.74	524.75	526.82	524.11
26520	530.84	531.29	530.90	524.88	526.88	524.57
26550	530.88	531.33	530.93	525.59	526.95	525.41
26860	531.27	531.73	531.33	525.84	527.17	525.63
28050	532.94	533.45	533.01	526.94	528.20	526.62
28165	533.23	533.74	533.29	527.01	528.36	526.69
28235	533.47	533.95	533.53	527.10	528.46	526.76
28300	533.61	534.09	533.67	527.26	528.86	526.88
28720	533.67	534.19	533.74	527.68	529.13	527.28
28980	536.46	537.01	536.53	528.33	530.14	527.84
29400	537.35	537.91	537.43	529.04	531.06	528.48
29422	537.76	538.34	537.84	528.95	531.05	528.39
29434	537.83	538.41	537.91	529.16	531.22	528.61
29512	537.88	538.45	537.96	529.68	531.59	529.12
30230	539.05	539.65	539.14	530.35	532.38	529.72

Table B-2. Water Surface Elevation for Applied Scenarios

HEC-2 Station	Flood Elevation for 100-Year Event (ft)			Flood Elevation for 1-Year Event (ft)		
	Existing	Future	Future-iSWM	Existing	Future	Future-iSWM
30620	538.93	539.47	539.00	530.59	532.60	529.97
30830	540.72	541.34	540.81	531.10	533.21	530.44
30860	540.79	541.40	540.88	531.17	533.29	530.51
30890	540.65	541.22	540.73	531.18	533.28	530.52
30910	541.97	543.25	542.12	531.25	533.39	530.58
30960	546.65	548.31	546.88	531.88	534.36	531.11
31080	547.97	549.72	548.21	531.99	534.49	531.22
31360	548.25	549.98	548.48	532.45	534.92	531.68
32500	548.54	550.24	548.78	533.86	536.28	532.52
32780	548.55	550.24	548.79	534.28	536.56	532.80
32880	548.58	550.26	548.82	534.41	536.72	532.89
32980	548.61	550.28	548.85	534.58	536.92	533.00
33080	548.66	550.29	548.89	534.78	537.15	533.15
33130	548.69	550.29	548.91	534.90	537.27	533.24
33180	548.85	550.68	549.08	535.04	537.49	533.34
33400	549.13	551.22	549.51	535.12	537.60	533.40
33480	550.75	552.61	551.17	535.47	538.06	533.66
33630	550.76	552.62	551.18	535.46	537.88	533.74
33960	550.81	552.66	551.23	536.58	539.14	534.58
34430	551.01	552.82	551.42	537.41	540.11	535.27
34480	551.15	552.91	551.55	537.50	540.21	535.33
34570	551.76	553.11	552.04	537.54	540.27	535.37
34630	551.77	553.12	552.05	537.16	539.79	535.16
35050	551.90	553.20	552.17	539.70	542.33	537.39
35510	552.39	553.60	552.65	540.48	543.11	538.13
35710	552.55	553.71	552.80	540.61	543.27	538.25
35755	552.87	554.07	553.14	540.66	543.34	538.28
35780	552.56	553.71	552.81	540.64	543.30	538.27
35820	561.44	563.75	562.03	540.72	543.44	538.32
35870	563.52	566.24	564.22	540.91	543.76	538.44
36000	564.77	567.49	565.47	540.70	543.78	538.14
36130	565.14	567.83	565.83	542.23	545.13	539.83
36720	565.31	567.99	566.00	543.62	546.28	541.35
36970	565.34	568.02	566.02	544.10	546.59	542.01
37340	565.38	568.05	566.06	544.59	546.92	542.56
37960	565.42	568.09	566.10	545.21	547.40	543.26

Table B-2. Water Surface Elevation for Applied Scenarios

HEC-2 Station	Flood Elevation for 100-Year Event (ft)			Flood Elevation for 1-Year Event (ft)		
	Existing	Future	Future-iSWM	Existing	Future	Future-iSWM
38200	565.44	568.11	566.12	545.65	548.05	544.45
39350	565.52	568.17	566.20	551.21	552.14	550.37
39640	565.53	568.17	566.20	551.30	552.22	550.46
40020	565.55	568.18	566.22	551.35	552.30	550.50
40230	565.55	568.17	566.22	551.58	552.71	550.63
40410	565.76	568.31	566.41	551.82	553.07	550.78
40620	565.97	568.48	566.62	551.97	553.28	550.88
40840	566.11	568.58	566.77	552.09	553.44	550.95
41030	566.25	568.71	566.91	552.23	553.61	551.06
41220	566.65	569.03	567.29	552.53	554.06	551.25
41250	566.68	569.04	567.32	552.54	554.07	551.26
41280	566.71	569.05	567.34	552.56	554.10	551.28
41310	566.72	569.06	567.36	552.59	554.13	551.30
41340	566.73	569.06	567.36	552.62	554.17	551.32
41350	566.73	569.05	567.36	552.63	554.18	551.33
41405	566.55	568.91	567.18	552.65	554.19	551.35
41450	568.30	570.08	568.82	552.69	554.26	551.37
41500	569.47	571.03	569.96	552.93	554.64	551.51
41825	569.60	571.14	570.09	553.13	554.89	551.67
42020	569.70	571.23	570.19	553.25	555.03	551.76
42230	569.81	571.35	570.30	553.38	555.17	551.87
42430	569.89	571.42	570.38	553.56	555.35	552.03
42630	569.99	571.51	570.48	553.78	555.59	552.24
42740	570.16	571.77	570.69	555.38	557.20	553.76
42810	570.65	572.12	571.13	559.06	561.43	556.80
43310	570.73	572.18	571.20	559.80	561.74	558.05
44540	570.84	572.28	571.31	561.21	562.05	560.35
45480	571.57	572.82	571.98	565.32	566.28	563.92
45860	571.87	572.99	572.23	566.06	567.04	564.57
46200	573.39	574.21	573.65	567.45	568.63	566.29
46500	574.74	575.41	574.96	569.55	570.35	568.39
46650	574.91	575.57	575.13	569.72	570.54	568.55
46980	576.67	577.26	576.88	570.20	571.32	568.86
47100	576.75	577.33	576.95	570.22	571.36	568.88
47220	577.29	578.01	577.54	570.28	571.45	568.92
47270	577.88	578.85	578.23	570.08	571.12	568.8

Table B-2. Water Surface Elevation for Applied Scenarios

HEC-2 Station	Flood Elevation for 100-Year Event (ft)			Flood Elevation for 1-Year Event (ft)		
	Existing	Future	Future-iSWM	Existing	Future	Future-iSWM
49300	578.40	579.25	578.7	570.81	572.05	569.42
50210	580.69	581.17	580.88	573.24	574.89	571.68
51410	585.43	585.97	585.69	576.21	578.12	574.27
52950	590.67	591.33	590.96	580.40	582.36	578.47
53820	593.92	594.54	594.22	583.81	585.76	582.13
54410	595.32	595.98	595.63	586.18	587.81	584.91
57110	599.45	600.06	599.74	591.29	592.53	590.25
57780	602.71	603.88	603.28	592.85	594.17	591.80
57830	602.05	602.99	602.54	593.89	594.85	593.21
57870	602.84	604.73	603.34	593.99	595.00	593.27
57920	605.84	607.84	606.47	594.43	595.58	593.59
58420	606.53	608.27	607.08	595.87	597.13	594.84
58620	606.79	608.46	607.32	596.22	597.54	595.13
58670	607.86	609.07	608.27	596.29	597.64	595.18
58770	607.93	609.13	608.34	596.43	597.81	595.31
58970	607.96	609.15	608.37	596.48	597.88	595.34
59070	607.96	609.16	608.37	596.65	598.05	595.51
59110	608.73	609.57	609.01	596.82	598.26	595.64
59160	608.74	609.58	609.01	597.09	598.48	595.99
59260	608.92	609.75	609.19	597.87	599.20	596.82
60540	612.16	612.81	612.31	604.16	605.42	603.05

Hydraulic Modeling Results

Review of table B-2 and the plots of floodplain maps for the 1- and 100-year storm events (Figures 5 and 6) indicate good agreement with the expectation of the modeling effort. The hydraulic modeling effort developed a comparison of the three watershed scenarios. Review of Table B-2 reveals a decrease in the water surface elevations of both the 1- and 100-year storm events between the future *without* iSWM conditions and the future *with* iSWM conditions scenarios. The plots of the floodplain maps reveal the width of the 100-year floodplain is reduced between the future *without* iSWM conditions and the future *with* iSWM conditions scenarios (see Figures 5 and 6 of the Summary).

Appendix C – Water Quality Analysis

The amount of total suspended solids (TSS) in a stream is a fair indicator of the overall water quality of the stream. Other pollutants attach themselves to the suspended solids and are transported downstream. Suspended solids interfere with the transmission of light and settle out in receiving streams and lakes. Turbid water is a result of excessive suspended solids in a stream. Reduction of TSS values in a stream has long been considered the best way to improve a stream's water quality and thus increase its potential uses.

The Simple Method was used to determine seasonal TSS loadings for the Big Fossil Creek Watershed. The Simple Method, developed by the Center for Watershed Protection, incorporates a land-use approach to estimating annual and/or seasonal non-point source loads from direct runoff based upon the event mean concentrations (EMCs) and runoff volumes. The approach is based on the fact that the type and concentration of pollutants in storm water is related to the amount of imperviousness and type of land use contributing to the runoff. Data required to execute the Simple Method water quality model include EMCs for TSS, land use, average annual/seasonal precipitation, and estimates for percent imperviousness on the sub-basin level. In summary, the Simple Method provides a basis for planning level evaluations of the long-term (annual or seasonal) non-point pollution loads and the relative benefits of non-point source pollution management strategies to reduce these loads.

During a storm event, the concentration of pollutants in the runoff varies considerably over time. For example, the concentration of oily substances on roadways are highest during the first part of the storm, and then decline quickly when the bulk of the material is washed off. This is known as the first-flush phenomenon. However, the concentration in the first-flush runoff is not representative of the entire storm. In order to estimate the loading from a storm, the flow-weighted average concentration is needed. Known as the Event Mean Concentration (EMC), the flow-weighted concentration is found by dividing the average of total loading by total runoff for a series of storm events.

The EMCs used in the Simple Method water quality model for the Big Fossil Creek Watershed were based upon a qualitative in-stream monitoring program completed by the NCTCOG. The NCTCOG completed a comprehensive sampling program of 22 separate outfalls for a wide range of pollutants, including total suspended solids. The sampling was conducted from September 1997 to August 2000. Although many other pollutants were included in the analysis, TSS is the pollutant of concern for this study. In order to model TSS values in the watershed, sampling sites were classified into five separate land use categories in order to differentiate water quality from diverse sources. For each sampling interval, the concentration and the quantity of runoff were combined to determine a TSS loading for the interval. At the end of the storm event, the results were used to develop the EMC (total mass/total runoff), which describes the average concentration for the storm. These results were combined with the results from several storm events and statistically evaluated to arrive at a representative EMC for each land use on a seasonal or average annual basis. Storm water loadings tend to be highly variable from one storm event to another, even for the same sampling site. This is attributable to variable antecedent weather conditions, which affect the amount of runoff; variable rainfall for a given event; seasonal variations in land use (e.g., spring fertilization of lawns); and other factors. Consequently, it is desirable to obtain a good statistical representation of the EMC.

A summary of the EMCs used in the Simple Method water quality model are presented in Table C-1.

Table C-1. Event Mean Concentrations, TSS (mg/l)

Type of Land Use	Season 1 (Sep – Oct)	Season 2 (Nov – Feb)	Season 3 (Mar – Jun)	Season 4 (Jul – Aug)
Commercial	41.5	37.5	46	37
Highway	62	142	134	142
Industrial	54	86	135	86
Open	118	332	118	332
Residential	90	73	116	73

Rainfall
The rainfall data used in the Simple Method water quality model were the long-term records of the National Weather Service recording station at Dallas/Fort Worth International Airport. Annual/Seasonal precipitation values were obtained from the National Oceanic and Atmospheric Association (NOAA).

Pollutant Data
As previously discussed, EMCs were derived from actual wet weather samples taken from 22 sites across the area. These sites were located within five different land uses types: commercial, industrial, highway, open, and residential.

Mapping
All mapping data was obtained from NCTCOG geographic information system. Digital base data included contours, orthophotographs, and existing and future land use. Basin and sub-basin boundaries were delineated during the development of the hydrologic models.

Model Development
The Simple Method water quality model was incorporated into a spreadsheet format for evaluation of the impacts on water quality from traditional non-point sources. The model is a user-friendly database model that simulates the generation and outcome of pollutant loads from a number of watershed pollutant sources. The model's primary function is to estimate pollutant loads from storm water runoff (non-point source pollution). For simulation of storm water runoff pollutant loads, the model uses land use and the associated runoff volume and event mean concentrations (EMCs) for total suspended solids.

Designated sub-basins within the Big Fossil Creek Watershed were simulated using existing and future land uses. The developed model is beneficial to NCTCOG future planning efforts because it can provide a forecast of the approximate impact of planned actions or alternatives on water quality and pollutant loads. The model may also be used to estimate and analyze trade-offs between planning objectives through the management of all watershed pollution sources (including non-point sources, such as storm water runoff, and point sources, such as wastewater treatment plant discharges, CSOs, etc.)

Land Use
The pollutant loading calculation is derived from land uses. Existing and future land use data, provided by the NCTCOG and the City of Fort Worth, were used as the basis for determining the land use classes employed in the water quality calculations. The provided land use was classified into the five land use types, as determined in the monitoring study completed by the NCTCOG; by grouping similar land use types. For example, regional commercial uses, office commercial uses, community commercial uses, and heavy commercial uses were all combined

into a larger "commercial" category. Table C-2 displays the land uses from the model and their corresponding percent imperviousness.

Table C-2.
Land Use Designations

Number	Description	Percent Imperviousness
1	Commercial	85
2	Highway	90
3	Industrial	72
4	Open	3
5	Residential	30

Pollutant Loads

Pollutant load is simply the product of runoff volume and event mean concentration. In order to generate the input data, land use-based runoff coefficients, land use-based EMCs, and rainfall depths are needed. Rainfall/runoff relationships are needed to estimate non-point pollution load factors (lbs/acre/year) for the various land use categories. The load factors are then used to calculate the annual load of a certain parameter from a drainage basin (lbs/year) based on the area of that land use.

The Simple Method estimates pollutant loads for chemical constituents as a product of annual runoff volume and pollutant concentration, as:

$$\mathbf{L = 0.226 * R * C * A}$$

L = Annual load (lbs)
R = Annual runoff (inches)
C = Pollutant concentration or Event Mean Concentration (mg/l)
A = Area (acres)
0.226 = Unit conversion factor

Annual Runoff

The Simple Method calculates annual runoff as a product of annual runoff volume, and a runoff coefficient (Rv). Runoff volume is calculated as:

$$\mathbf{R = P * P_j * Rv}$$

R = Annual runoff (inches)
P = Annual rainfall (inches)
P_j = Fraction of annual rainfall events that produce runoff (usually 0.9)
Rv = Runoff coefficient

For the modeling, a runoff coefficient of (0.05 + 0.009(I)) was used to predict runoff, where I is the percent of impervious area. For completely pervious surfaces, the R_v would be 0.05. For completely impervious surfaces, the R_v would be 0.95.

iSWM Application
In order to simulate the future conditions *with* iSWM scenario, a 75 percent reduction in TSS loadings was applied to each sub-basin. This application was made to reflect the design recommendations of the iSWM structural Best Management Practices (BMPs). Recommended water quality BMPs will remove 80 percent of the average annual TSS load in typical urban post-development runoff and a proportional removal of other pollutants, if designed and installed properly.

Model Results
Table C-3 presents the TSS loadings computed for each sub-basin for the existing conditions scenario and the future conditions scenarios, both *without* and *with* iSWM design criteria. Red text denotes application of iSWM design criteria for Future Conditions.

Table C-3. Comparison of TSS Loadings

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	580	745	1,440	328	308	395	765	174	231	297	574	131
BF1	Highway	5,137	16,953	24,889	7,477	6,186	20,417	29,975	9,004	4,640	15,313	22,481	6,753
	Industrial	570	1,307	3,193	577	3,525	8,091	19,760	3,568	2,644	6,068	14,820	2,676
	Open	6,815	27,629	15,278	12,185	158	642	355	283	158	642	355	283
	Residential	672	786	1,942	346	19,177	22,415	55,415	9,885	14,383	16,811	41,561	7,414
	Total	**13,772**	**47,420**	**46,743**	**20,913**	**29,355**	**51,960**	**106,269**	**22,915**	**22,055**	**39,130**	**79,790**	**17,257**
	Commercial	0	348	0	0	0	348	1	0	0	261	1	0
BF2	Highway	1,087	3,588	5,267	1,582	955	3,153	4,629	1,391	717	2,365	3,472	1,043
	Industrial	0	0	0	0	5,277	12,111	29,578	5,341	3,958	9,083	22,183	4,006
	Open	6,219	25,215	13,943	11,120	3	13	7	6	3	13	7	6
	Residential	0	0	0	0	15,741	18,399	45,486	8,114	11,806	13,799	34,115	6,086
	Total	**7,306**	**29,151**	**19,210**	**12,703**	**21,977**	**34,024**	**79,701**	**14,852**	**16,484**	**25,521**	**59,778**	**11,140**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BF3	Highway	681	2,246	3,298	991	662	2,185	3,209	964	497	1,639	2,406	723
	Industrial	0	0	0	0	166	380	929	168	124	285	697	126
	Open	6,699	27,161	15,019	11,979	25	100	55	44	25	100	55	44
	Residential	1,254	1,466	3,624	647	22,293	26,058	64,420	11,492	16,720	19,543	48,315	8,619
	Total	**8,634**	**30,873**	**21,941**	**13,616**	**23,146**	**28,724**	**68,613**	**12,668**	**17,366**	**21,568**	**51,473**	**9,512**
	Commercial	0	0	0	0	888	1,141	2,207	503	666	856	1,655	377
BF4	Highway	1,041	3,436	5,044	1,515	1,006	3,319	4,873	1,464	754	2,489	3,655	1,098
	Industrial	2,648	6,078	14,844	2,680	9,101	20,886	51,010	9,211	6,826	15,665	38,257	6,909
	Open	5,979	24,241	13,404	10,691	709	2,873	1,588	1,267	709	2,873	1,588	1,267
	Residential	6,106	7,137	17,644	3,147	17,143	20,038	49,538	8,837	12,858	15,029	37,154	6,628
	Total	**15,774**	**40,891**	**50,936**	**18,034**	**28,847**	**48,257**	**109,216**	**21,282**	**21,812**	**36,911**	**82,309**	**16,279**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	0	0	0	0	116	149	288	66	116	149	288	66
BF5	Highway	436	1,437	2,110	634	1,131	3,733	5,480	1,646	1,131	3,733	5,480	1,646
	Industrial	152	348	850	154	0	0	0	0	0	0	0	0
	Open	2,843	11,528	6,374	5,084	148	599	331	264	148	599	331	264
	Residential	8,461	9,890	24,449	4,362	16,647	19,458	48,104	8,581	16,647	19,458	48,104	8,581
	Total	**11,891**	**23,203**	**33,784**	**10,233**	**18,042**	**23,938**	**54,203**	**10,557**	**18,042**	**23,938**	**54,203**	**10,557**
	Commercial	0	0	0	0	221	285	550	125	166	213	413	94
BF6	Highway	781	2,578	3,785	1,137	2,304	7,603	11,163	3,353	1,728	5,703	8,372	2,515
	Industrial	2,471	5,670	13,847	2,501	2,605	5,978	14,599	2,636	1,954	4,483	10,950	1,977
	Open	2,718	11,021	6,094	4,861	72	293	162	129	72	293	162	129
	Residential	0	0	0	0	7,274	8,502	21,018	3,749	5,455	6,376	15,764	2,812
	Total	**5,970**	**19,269**	**23,727**	**8,498**	**12,476**	**22,661**	**47,493**	**9,994**	**9,375**	**17,069**	**35,660**	**7,528**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BF7	Highway	1,895	6,255	9,183	2,758	1,940	6,402	9,399	2,823	1,455	4,802	7,049	2,118
	Industrial	2,554	5,861	14,313	2,585	2,466	5,660	13,822	2,496	1,850	4,245	10,367	1,872
	Open	4,378	17,749	9,814	7,828	290	1,174	649	518	290	1,174	649	518
	Residential	2,151	2,514	6,215	1,109	15,151	17,710	43,782	7,810	11,363	13,282	32,836	5,858
	Total	**10,977**	**32,378**	**39,526**	**14,279**	**19,847**	**30,946**	**67,652**	**13,648**	**14,958**	**23,503**	**50,902**	**10,365**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BF8	Highway	135	444	652	196	890	2,938	4,314	1,296	668	2,204	3,235	972
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	2,200	8,918	4,931	3,933	7	30	17	13	7	30	17	13
	Residential	1,476	1,725	4,264	761	8,016	9,369	23,163	4,132	6,012	7,027	17,372	3,099
	Total	**3,810**	**11,087**	**9,848**	**4,890**	**8,913**	**12,337**	**27,493**	**5,441**	**6,687**	**9,260**	**20,624**	**4,084**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	0	1	1	0	774	994	1,922	438	580	745	1,442	329
BF9	Highway	2,596	8,569	12,580	3,779	1,528	5,044	7,405	2,225	1,146	3,783	5,554	1,668
	Industrial	0	0	0	0	537	1,232	3,008	543	403	924	2,256	407
	Open	5,048	20,466	11,317	9,026	877	3,555	1,966	1,568	877	3,555	1,966	1,568
	Residential	1,174	1,373	3,393	605	13,904	16,252	40,178	7,167	10,428	12,189	30,134	5,376
	Total	**8,819**	**30,408**	**27,292**	**13,411**	**17,620**	**27,076**	**54,480**	**11,941**	**13,434**	**21,196**	**41,351**	**9,348**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BF10	Highway	479	1,580	2,320	697	674	2,225	3,267	981	506	1,669	2,450	736
	Industrial	0	0	0	0	1,355	3,109	7,593	1,371	1,016	2,332	5,695	1,028
	Open	4,116	16,687	9,227	7,359	1	3	2	2	1	3	2	2
	Residential	2,300	2,688	6,646	1,186	14,203	16,601	41,041	7,321	10,652	12,451	30,780	5,491
	Total	**6,895**	**20,955**	**18,193**	**9,242**	**16,232**	**21,938**	**51,902**	**9,675**	**12,175**	**16,455**	**38,927**	**7,257**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BF11	Highway	46	152	223	67	210	692	1,016	305	157	519	762	229
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	2,600	10,543	5,830	4,650	5	21	11	9	5	21	11	9
	Residential	265	309	765	136	8,402	9,821	24,279	4,331	6,302	7,366	18,209	3,248
	Total	**2,911**	**11,004**	**6,818**	**4,853**	**8,617**	**10,533**	**25,306**	**4,645**	**6,464**	**7,905**	**18,982**	**3,486**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BF12	Highway	2,234	7,374	10,827	3,252	599	1,977	2,903	872	449	1,483	2,177	654
	Industrial	0	0	0	0	2,326	5,338	13,036	2,354	1,744	4,003	9,777	1,766
	Open	8,893	36,057	19,938	15,902	283	1,146	634	506	283	1,146	634	506
	Residential	0	0	0	0	26,399	30,856	76,284	13,608	19,799	23,142	57,213	10,206
	Total	**11,128**	**43,431**	**30,765**	**19,154**	**29,607**	**39,318**	**92,857**	**17,340**	**22,276**	**29,775**	**69,801**	**13,131**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	300	385	745	170	618	794	1,535	350	463	595	1,151	262
BF13	Highway	946	3,123	4,585	1,377	989	3,263	4,790	1,439	741	2,447	3,593	1,079
	Industrial	19	44	107	19	580	1,332	3,252	587	435	999	2,439	440
	Open	4,972	20,159	11,147	8,891	2,193	8,892	4,917	3,922	2,193	8,892	4,917	3,922
	Residential	0	0	0	0	8,408	9,827	24,296	4,334	6,306	7,371	18,222	3,251
	Total	**6,237**	**23,711**	**16,583**	**10,457**	**12,788**	**24,108**	**38,790**	**10,632**	**10,139**	**20,304**	**30,322**	**8,955**
	Commercial	387	498	962	219	2,376	3,052	5,903	1,346	1,782	2,289	4,428	1,010
BF14	Highway	1,517	5,007	7,350	2,208	4,147	13,688	20,095	6,037	3,110	10,266	15,072	4,527
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	5,681	23,032	12,736	10,158	4,122	16,712	9,241	7,370	4,122	16,712	9,241	7,370
	Residential	3,567	4,170	10,308	1,839	5,674	6,632	16,395	2,925	4,255	4,974	12,296	2,193
	Total	**11,152**	**32,706**	**31,357**	**14,424**	**16,318**	**40,083**	**51,634**	**17,677**	**13,269**	**34,240**	**41,036**	**15,101**
	Commercial	33	42	81	19	771	991	1,917	437	578	743	1,438	328
BF15	Highway	1,614	5,327	7,821	2,349	2,039	6,729	9,880	2,968	1,529	5,047	7,410	2,226
	Industrial	0	0	0	0	2,878	6,605	16,131	2,913	2,159	4,954	12,099	2,185
	Open	3,940	15,974	8,833	7,045	3,610	14,638	8,094	6,456	3,610	14,638	8,094	6,456
	Residential	1,557	1,820	4,499	803	9,987	11,674	28,860	5,148	7,490	8,755	21,645	3,861
	Total	**7,144**	**23,163**	**21,234**	**10,215**	**19,286**	**40,637**	**64,882**	**17,922**	**15,367**	**34,137**	**50,685**	**15,055**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BF16	Highway	2,202	7,267	10,669	3,205	2,783	9,184	13,483	4,050	2,087	6,888	10,112	3,038
	Industrial	1,920	4,407	10,764	1,944	7,083	16,256	39,702	7,169	5,313	12,192	29,776	5,377
	Open	7,883	31,963	17,674	14,096	3,516	14,254	7,882	6,286	3,516	14,254	7,882	6,286
	Residential	0	0	0	0	20,479	23,937	59,178	10,557	15,360	17,953	44,384	7,918
	Total	**12,006**	**43,637**	**39,107**	**19,245**	**33,861**	**63,631**	**120,244**	**28,063**	**26,275**	**51,287**	**92,154**	**22,619**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	0	0	0	0	8,759	11,254	21,767	4,963	6,569	8,440	16,325	3,722
BF17	Highway	0	0	0	0	0	0	0	0	0	0	0	0
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	5,179	20,998	11,611	9,261	5,159	20,918	11,567	9,225	5,159	20,918	11,567	9,225
	Residential	0	0	0	0	8,958	10,470	25,884	4,617	6,718	7,852	19,413	3,463
	Total	**5,179**	**20,998**	**11,611**	**9,261**	**22,876**	**42,642**	**59,218**	**18,806**	**18,447**	**37,211**	**47,305**	**16,411**
	Commercial	4,217	5,418	10,480	2,390	5	7	13	3	4	5	10	2
BF18	Highway	2,122	7,005	10,284	3,089	2,656	8,767	12,872	3,867	1,992	6,576	9,654	2,900
	Industrial	818	1,877	4,585	828	21,242	48,749	119,057	21,499	15,931	36,562	89,293	16,125
	Open	3,766	15,269	8,443	6,734	3,159	12,807	7,082	5,648	3,159	12,807	7,082	5,648
	Residential	1,546	1,807	4,468	797	1,552	1,813	4,483	800	1,164	1,360	3,362	600
	Total	**12,470**	**31,377**	**38,261**	**13,838**	**28,614**	**72,144**	**143,507**	**31,817**	**22,250**	**57,310**	**109,401**	**25,275**
	Commercial	1,544	1,984	3,838	875	681	876	1,694	386	511	657	1,270	290
BF19	Highway	8,105	26,751	39,275	11,798	9,452	31,195	45,798	13,757	7,089	23,396	34,348	10,318
	Industrial	0	0	0	0	22,699	52,095	127,228	22,975	17,025	39,071	95,421	17,231
	Open	5,361	21,735	12,019	9,586	1,386	5,621	3,108	2,479	1,386	5,621	3,108	2,479
	Residential	2,086	2,438	6,026	1,075	1,704	1,992	4,924	878	1,278	1,494	3,693	659
	Total	**17,096**	**52,909**	**61,158**	**23,334**	**35,923**	**91,777**	**182,752**	**40,476**	**27,289**	**70,238**	**137,841**	**30,976**
	Commercial	545	701	1,355	309	2,717	3,490	6,751	1,539	2,037	2,618	5,063	1,154
BF20	Highway	1,331	4,392	6,448	1,937	1,351	4,457	6,544	1,966	1,013	3,343	4,908	1,474
	Industrial	1,435	3,293	8,042	1,452	16,452	37,756	92,209	16,651	12,339	28,317	69,157	12,488
	Open	3,665	14,860	8,217	6,553	27	109	60	48	27	109	60	48
	Residential	1,801	2,105	5,204	928	0	0	0	0	0	0	0	0
	Total	**8,777**	**25,350**	**29,266**	**11,180**	**20,545**	**45,812**	**105,564**	**20,204**	**15,416**	**34,386**	**79,188**	**15,165**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	0	0	0	0	150	192	372	85	112	144	279	64
BF21	Highway	83	273	401	121	130	428	628	189	97	321	471	141
	Industrial	74	169	412	74	3,229	7,409	18,096	3,268	2,421	5,557	13,572	2,451
	Open	805	3,265	1,805	1,440	0	1	1	1	0	1	1	1
	Residential	12	14	34	6	0	0	1	0	0	0	1	0
	Total	**974**	**3,721**	**2,654**	**1,641**	**3,508**	**8,031**	**19,097**	**3,542**	**2,631**	**6,024**	**14,323**	**2,657**
	Commercial	2,779	3,571	6,907	1,575	4,680	6,013	11,630	2,652	4,680	6,013	11,630	2,652
BF22	Highway	2,984	9,847	14,457	4,343	4,268	14,087	20,682	6,213	4,268	14,087	20,682	6,213
	Industrial	1,872	4,297	10,494	1,895	1,330	3,053	7,455	1,346	1,330	3,053	7,455	1,346
	Open	2,135	8,658	4,787	3,818	1,337	5,422	2,998	2,391	1,337	5,422	2,998	2,391
	Residential	5,206	6,085	15,044	2,684	5,838	6,823	16,869	3,009	5,838	6,823	16,869	3,009
	Total	**14,977**	**32,458**	**51,690**	**14,315**	**17,453**	**35,398**	**59,635**	**15,611**	**17,453**	**35,398**	**59,635**	**15,611**
	Commercial	6,936	8,911	17,236	3,930	4,106	5,275	10,202	2,326	4,106	5,275	10,202	2,326
BF23	Highway	2,278	7,517	11,036	3,315	2,416	7,975	11,709	3,517	2,416	7,975	11,709	3,517
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	1,503	6,093	3,369	2,687	2,088	8,466	4,681	3,734	2,088	8,466	4,681	3,734
	Residential	1,631	1,906	4,713	841	2,112	2,468	6,102	1,088	2,112	2,468	6,102	1,088
	Total	**12,347**	**24,427**	**36,354**	**10,773**	**10,721**	**24,184**	**32,694**	**10,665**	**10,721**	**24,184**	**32,694**	**10,665**
	Commercial	821	1,055	2,041	465	5,658	7,269	14,060	3,206	4,243	5,452	10,545	2,404
BF24	Highway	3,704	12,224	17,947	5,391	2,896	9,558	14,032	4,215	2,172	7,168	10,524	3,161
	Industrial	1,956	4,490	10,966	1,980	0	0	0	0	0	0	0	0
	Open	1,920	7,785	4,305	3,433	1,148	4,653	2,573	2,052	1,148	4,653	2,573	2,052
	Residential	1,872	2,189	5,411	965	2,134	2,495	6,168	1,100	1,601	1,871	4,626	825
	Total	**10,274**	**27,743**	**40,669**	**12,235**	**11,836**	**23,974**	**36,832**	**10,573**	**9,164**	**19,144**	**28,267**	**8,443**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	2,650	3,405	6,587	1,502	5,569	7,155	13,839	3,155	5,569	7,155	13,839	3,155
BF25	Highway	9,750	32,179	47,243	14,191	7,908	26,099	38,317	11,510	7,908	26,099	38,317	11,510
	Industrial	1,910	4,384	10,708	1,934	702	1,611	3,934	710	702	1,611	3,934	710
	Open	3,307	13,406	7,413	5,912	2,554	10,353	5,725	4,566	2,554	10,353	5,725	4,566
	Residential	2,917	3,409	8,428	1,504	4,737	5,537	13,688	2,442	4,737	5,537	13,688	2,442
	Total	**20,534**	**56,784**	**80,378**	**25,043**	**21,469**	**50,754**	**75,502**	**22,384**	**21,469**	**50,754**	**75,502**	**22,384**
	Commercial	2,229	2,863	5,538	1,263	7,905	10,156	19,644	4,479	7,905	10,156	19,644	4,479
BF26	Highway	7,775	25,662	37,675	11,317	5,935	19,589	28,760	8,639	5,935	19,589	28,760	8,639
	Industrial	70	160	390	70	0	0	0	0	0	0	0	0
	Open	1,797	7,288	4,030	3,214	715	2,900	1,603	1,279	715	2,900	1,603	1,279
	Residential	7,610	8,895	21,991	3,923	7,255	8,479	20,963	3,740	7,255	8,479	20,963	3,740
	Total	**19,481**	**44,868**	**69,624**	**19,788**	**21,810**	**41,124**	**70,970**	**18,137**	**21,810**	**41,124**	**70,970**	**18,137**
	Commercial	207	265	514	117	3,048	3,916	7,575	1,727	2,286	2,937	5,681	1,295
BF27	Highway	3,678	12,138	17,820	5,353	3,385	11,173	16,403	4,927	2,539	8,379	12,302	3,696
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	1,680	6,810	3,766	3,004	1,065	4,319	2,388	1,905	1,065	4,319	2,388	1,905
	Residential	5,833	6,818	16,855	3,007	5,520	6,452	15,951	2,846	4,140	4,839	11,963	2,134
	Total	**11,397**	**26,032**	**38,955**	**11,481**	**13,019**	**25,859**	**42,317**	**11,405**	**10,030**	**20,474**	**32,335**	**9,030**
	Commercial	1,453	1,867	3,611	823	2,914	3,744	7,242	1,651	2,914	3,744	7,242	1,651
BF28	Highway	8,571	28,287	41,529	12,475	6,907	22,796	33,468	10,054	6,907	22,796	33,468	10,054
	Industrial	1,978	4,541	11,089	2,002	1,646	3,777	9,223	1,666	1,646	3,777	9,223	1,666
	Open	538	2,180	1,206	962	486	1,972	1,091	870	486	1,972	1,091	870
	Residential	9,685	11,320	27,986	4,993	9,757	11,404	28,193	5,029	9,757	11,404	28,193	5,029
	Total	**22,225**	**48,195**	**85,422**	**21,255**	**21,710**	**43,693**	**79,217**	**19,270**	**21,710**	**43,693**	**79,217**	**19,270**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	86	111	214	49	4,781	6,142	11,880	2,709	3,586	4,607	8,910	2,032
BF29	Highway	4,474	14,765	21,677	6,512	4,014	13,248	19,450	5,843	3,011	9,936	14,588	4,382
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	1,701	6,896	3,813	3,041	365	1,479	818	652	365	1,479	818	652
	Residential	7,543	8,817	21,798	3,888	8,029	9,385	23,201	4,139	6,022	7,039	17,401	3,104
	Total	**13,804**	**30,589**	**47,502**	**13,490**	**17,189**	**30,254**	**55,350**	**13,343**	**12,983**	**23,060**	**41,717**	**10,170**
	Commercial	3,280	4,214	8,151	1,858	6,416	8,244	15,945	3,636	6,416	8,244	15,945	3,636
BF30	Highway	10,576	34,906	51,247	15,394	8,247	27,219	39,961	12,004	8,247	27,219	39,961	12,004
	Industrial	1,342	3,079	7,520	1,358	231	531	1,296	234	231	531	1,296	234
	Open	661	2,682	1,483	1,183	661	2,681	1,482	1,182	661	2,681	1,482	1,182
	Residential	13,653	15,958	39,451	7,038	13,089	15,299	37,823	6,747	13,089	15,299	37,823	6,747
	Total	**29,512**	**60,839**	**107,852**	**26,831**	**28,645**	**53,973**	**96,508**	**23,803**	**28,645**	**53,973**	**96,508**	**23,803**
	Commercial	3,617	4,647	8,988	2,049	5,854	7,522	14,549	3,317	5,854	7,522	14,549	3,317
BF31	Highway	6,360	20,990	30,816	9,257	4,312	14,230	20,892	6,276	4,312	14,230	20,892	6,276
	Industrial	1,005	2,307	5,634	1,017	0	0	0	0	0	0	0	0
	Open	2,116	8,579	4,744	3,783	2,065	8,372	4,629	3,692	2,065	8,372	4,629	3,692
	Residential	3,347	3,912	9,671	1,725	3,478	4,065	10,049	1,793	3,478	4,065	10,049	1,793
	Total	**16,444**	**40,434**	**59,852**	**17,832**	**15,708**	**34,188**	**50,118**	**15,078**	**15,708**	**34,188**	**50,118**	**15,078**
	Commercial	2,114	2,716	5,254	1,198	2,498	3,209	6,207	1,415	2,498	3,209	6,207	1,415
BF32	Highway	4,397	14,513	21,307	6,400	4,330	14,291	20,981	6,302	4,330	14,291	20,981	6,302
	Industrial	57	130	317	57	0	0	0	0	0	0	0	0
	Open	812	3,292	1,820	1,452	549	2,227	1,232	982	549	2,227	1,232	982
	Residential	7,973	9,319	23,039	4,110	8,558	10,003	24,729	4,411	8,558	10,003	24,729	4,411
	Total	**15,353**	**29,970**	**51,737**	**13,217**	**15,935**	**29,730**	**53,148**	**13,111**	**15,935**	**29,730**	**53,148**	**13,111**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	2,776	3,566	6,898	1,573	4,169	5,357	10,361	2,362	4,169	5,357	10,361	2,362
BF33	Highway	9,673	31,924	46,869	14,079	9,073	29,946	43,966	13,207	9,073	29,946	43,966	13,207
	Industrial	284	651	1,591	287	52	118	289	52	52	118	289	52
	Open	1,143	4,635	2,563	2,044	590	2,392	1,323	1,055	590	2,392	1,323	1,055
	Residential	12,227	14,291	35,331	6,303	13,295	15,539	38,416	6,853	13,295	15,539	38,416	6,853
	Total	**26,102**	**55,068**	**93,252**	**24,286**	**27,179**	**53,352**	**94,355**	**23,529**	**27,179**	**53,352**	**94,355**	**23,529**
	Commercial	467	600	1,160	264	11,109	14,273	27,608	6,295	11,109	14,273	27,608	6,295
BF34	Highway	6,365	21,008	30,843	9,265	4,960	16,369	24,031	7,219	4,960	16,369	24,031	7,219
	Industrial	4,323	9,922	24,232	4,376	545	1,250	3,053	551	545	1,250	3,053	551
	Open	3,273	13,272	7,339	5,853	1,558	6,317	3,493	2,786	1,558	6,317	3,493	2,786
	Residential	947	1,107	2,736	488	968	1,131	2,797	499	968	1,131	2,797	499
	Total	**15,376**	**45,909**	**66,310**	**20,247**	**19,140**	**39,340**	**60,982**	**17,350**	**19,140**	**39,340**	**60,982**	**17,350**
	Commercial	0	0	0	0	0	1	1	0	0	0	1	0
BFA40	Highway	4,965	16,387	24,059	7,227	4,467	14,744	21,646	6,502	3,350	11,058	16,235	4,877
	Industrial	239	548	1,338	242	0	0	0	0	0	0	0	0
	Open	3,400	13,787	7,624	6,080	30	122	68	54	30	122	68	54
	Residential	0	0	0	0	11,134	13,014	32,172	5,739	8,350	9,760	24,129	4,304
	Total	**8,604**	**30,722**	**33,021**	**13,549**	**15,632**	**27,881**	**53,888**	**12,296**	**11,731**	**20,941**	**40,433**	**9,235**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BFA41	Highway	126	416	611	183	268	886	1,301	391	268	886	1,301	391
	Industrial	734	1,685	4,116	743	0	0	0	0	0	0	0	0
	Open	3,133	12,704	7,025	5,603	1,166	4,730	2,615	2,086	1,166	4,730	2,615	2,086
	Residential	3,135	3,664	9,058	1,616	9,853	11,517	28,473	5,079	9,853	11,517	28,473	5,079
	Total	**7,129**	**18,470**	**20,810**	**8,145**	**11,288**	**17,132**	**32,389**	**7,556**	**11,288**	**17,132**	**32,389**	**7,556**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	88	113	219	50	96	124	239	54	96	124	239	54
BFA42	Highway	2,694	8,891	13,054	3,921	2,811	9,277	13,620	4,091	2,811	9,277	13,620	4,091
	Industrial	0	0	0	0	120	276	673	122	120	276	673	122
	Open	2,190	8,881	4,911	3,917	1,345	5,453	3,015	2,405	1,345	5,453	3,015	2,405
	Residential	10,068	11,767	29,092	5,190	12,586	14,711	36,369	6,488	12,586	14,711	36,369	6,488
	Total	**15,040**	**29,653**	**47,275**	**13,078**	**16,958**	**29,840**	**53,917**	**13,160**	**16,958**	**29,840**	**53,917**	**13,160**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BFA43	Highway	1,423	4,698	6,897	2,072	1,246	4,114	6,040	1,814	935	3,085	4,530	1,361
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	5,032	20,402	11,282	8,998	1	3	2	1	1	3	2	1
	Residential	0	0	0	0	16,043	18,752	46,360	8,270	12,033	14,064	34,770	6,203
	Total	**6,455**	**25,100**	**18,179**	**11,070**	**17,291**	**22,869**	**52,401**	**10,086**	**12,968**	**17,152**	**39,301**	**7,565**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BFA44	Highway	562	1,854	2,721	817	486	1,603	2,354	707	364	1,203	1,766	530
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	4,396	17,822	9,855	7,860	5	21	12	9	5	21	12	9
	Residential	0	0	0	0	13,957	16,314	40,331	7,195	10,468	12,235	30,248	5,396
	Total	**4,957**	**19,676**	**12,576**	**8,677**	**14,448**	**17,938**	**42,697**	**7,911**	**10,837**	**13,459**	**32,025**	**5,936**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BFA45	Highway	624	2,059	3,023	908	552	1,821	2,673	803	552	1,821	2,673	803
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	7,334	29,737	16,444	13,115	83	337	186	148	83	337	186	148
	Residential	1,644	1,921	4,750	847	24,668	28,833	71,282	12,716	24,668	28,833	71,282	12,716
	Total	**9,602**	**33,718**	**24,217**	**14,870**	**25,303**	**30,991**	**74,141**	**13,667**	**25,303**	**30,991**	**74,141**	**13,667**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BFA46	Highway	35	117	172	52	0	0	0	0	0	0	0	0
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	1,832	7,427	4,107	3,276	0	0	0	0	0	0	0	0
	Residential	0	0	0	0	5,825	6,809	16,833	3,003	4,369	5,107	12,625	2,252
	Total	**1,867**	**7,544**	**4,279**	**3,327**	**5,825**	**6,809**	**16,833**	**3,003**	**4,369**	**5,107**	**12,625**	**2,252**
	Commercial	403	517	1,000	228	62	80	154	35	62	80	154	35
BFA47	Highway	4,383	14,466	21,238	6,380	4,117	13,589	19,951	5,993	4,117	13,589	19,951	5,993
	Industrial	1,079	2,477	6,050	1,092	3,612	8,288	20,242	3,655	3,612	8,288	20,242	3,655
	Open	5,385	21,833	12,073	9,629	571	2,313	1,279	1,020	571	2,313	1,279	1,020
	Residential	8,060	9,421	23,290	4,155	21,818	25,502	63,046	11,247	21,818	25,502	63,046	11,247
	Total	**19,310**	**48,714**	**63,650**	**21,484**	**30,179**	**49,773**	**104,673**	**21,951**	**30,179**	**49,773**	**104,673**	**21,951**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BFA48	Highway	2,525	8,333	12,234	3,675	2,989	9,866	14,485	4,351	2,242	7,400	10,864	3,263
	Industrial	2,778	6,377	15,573	2,812	9,964	22,867	55,847	10,085	7,473	17,150	41,885	7,564
	Open	3,788	15,359	8,493	6,774	0	0	0	0	0	0	0	0
	Residential	0	0	0	0	6,266	7,324	18,107	3,230	4,700	5,493	13,580	2,423
	Total	**9,091**	**30,069**	**36,300**	**13,261**	**19,219**	**40,058**	**88,439**	**17,666**	**14,415**	**30,043**	**66,329**	**13,250**
	Commercial	0	0	0	0	5	6	12	3	4	5	9	2
BFA49	Highway	1,356	4,476	6,571	1,974	2,414	7,968	11,698	3,514	1,811	5,976	8,774	2,636
	Industrial	2,042	4,685	11,443	2,066	4,154	9,533	23,281	4,204	3,115	7,150	17,461	3,153
	Open	3,432	13,913	7,693	6,136	1,078	4,371	2,417	1,928	1,078	4,371	2,417	1,928
	Residential	0	0	0	0	8,310	9,713	24,014	4,284	6,233	7,285	18,010	3,213
	Total	**6,829**	**23,074**	**25,708**	**10,176**	**15,961**	**31,591**	**61,422**	**13,932**	**12,240**	**24,786**	**46,671**	**10,931**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	639	821	1,589	362	0	0	0	0	0	0	0	0
BFB50	Highway	1,819	6,002	8,812	2,647	1,313	4,333	6,362	1,911	985	3,250	4,772	1,433
	Industrial	1,470	3,373	8,238	1,488	6,449	14,801	36,146	6,527	4,837	11,100	27,110	4,896
	Open	3,332	13,508	7,470	5,957	631	2,559	1,415	1,129	631	2,559	1,415	1,129
	Residential	8,870	10,367	25,630	4,572	14,443	16,881	41,735	7,445	10,832	12,661	31,301	5,584
	Total	**16,129**	**34,072**	**51,739**	**15,027**	**22,836**	**38,575**	**85,658**	**17,012**	**17,285**	**29,571**	**64,597**	**13,041**
	Commercial	289	371	718	164	0	0	0	0	0	0	0	0
BFB51	Highway	4,471	14,756	21,664	6,508	5,619	18,545	27,226	8,179	4,214	13,909	20,420	6,134
	Industrial	307	705	1,723	311	22,759	52,232	127,562	23,035	17,069	39,174	95,671	17,276
	Open	7,923	32,122	17,762	14,167	0	0	0	0	0	0	0	0
	Residential	0	0	0	0	7,583	8,863	21,912	3,909	5,687	6,648	16,434	2,932
	Total	**12,990**	**47,954**	**41,867**	**21,149**	**35,961**	**79,640**	**176,701**	**35,123**	**26,971**	**59,730**	**132,526**	**26,342**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BFB52	Highway	2,800	9,242	13,569	4,076	3,049	10,065	14,776	4,439	2,287	7,549	11,082	3,329
	Industrial	0	0	0	0	10,938	25,103	61,307	11,071	8,204	18,827	45,981	8,303
	Open	4,702	19,062	10,541	8,407	0	0	0	0	0	0	0	0
	Residential	347	405	1,001	179	6,757	7,898	19,525	3,483	5,068	5,923	14,644	2,612
	Total	**7,848**	**28,709**	**25,111**	**12,661**	**20,745**	**43,066**	**95,609**	**18,993**	**15,559**	**32,300**	**71,707**	**14,245**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BFB53	Highway	1,385	4,572	6,712	2,016	1,217	4,016	5,895	1,771	913	3,012	4,422	1,328
	Industrial	2,058	4,722	11,532	2,083	9,851	22,608	55,213	9,970	7,388	16,956	41,410	7,478
	Open	6,572	26,645	14,734	11,751	102	412	228	182	102	412	228	182
	Residential	889	1,039	2,568	458	15,533	18,156	44,885	8,007	11,650	13,617	33,664	6,005
	Total	**10,903**	**36,978**	**35,546**	**16,308**	**26,702**	**45,191**	**106,221**	**19,930**	**20,052**	**33,997**	**79,723**	**14,993**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BFB54	Highway	9,895	32,658	47,946	14,403	9,615	31,734	46,591	13,996	7,211	23,801	34,943	10,497
	Industrial	553	1,268	3,098	559	6,127	14,061	34,339	6,201	4,595	10,545	25,754	4,651
	Open	5,684	23,047	12,744	10,164	4,334	17,574	9,718	7,750	4,334	17,574	9,718	7,750
	Residential	0	0	0	0	13,861	16,202	40,055	7,145	10,396	12,151	30,041	5,359
	Total	**16,132**	**56,973**	**63,788**	**25,126**	**33,938**	**79,571**	**130,702**	**35,092**	**26,537**	**64,072**	**100,456**	**28,257**
	Commercial	0	0	0	0	0	0	0	0	0	0	0	0
BFB55	Highway	728	2,403	3,528	1,060	326	1,075	1,579	474	244	806	1,184	356
	Industrial	0	0	0	0	821	1,883	4,599	830	615	1,412	3,449	623
	Open	2,020	8,190	4,529	3,612	0	0	0	0	0	0	0	0
	Residential	0	0	0	0	5,993	7,004	17,316	3,089	4,494	5,253	12,987	2,317
	Total	**2,748**	**10,593**	**8,056**	**4,672**	**7,139**	**9,963**	**23,494**	**4,394**	**5,354**	**7,472**	**17,620**	**3,295**
	Commercial	1,637	2,103	4,067	927	236	303	586	134	236	303	586	134
BFB56	Highway	2,108	6,956	10,212	3,068	4,473	14,763	21,674	6,511	4,473	14,763	21,674	6,511
	Industrial	0	0	0	0	4,866	11,168	27,274	4,925	4,866	11,168	27,274	4,925
	Open	2,406	9,757	5,395	4,303	63	254	141	112	63	254	141	112
	Residential	4,254	4,972	12,291	2,193	8,164	9,543	23,591	4,209	8,164	9,543	23,591	4,209
	Total	**10,404**	**23,787**	**31,966**	**10,491**	**17,802**	**36,031**	**73,266**	**15,890**	**17,802**	**36,031**	**73,266**	**15,890**
	Commercial	7	9	17	4	55	70	136	31	41	53	102	23
BFB57	Highway	2,955	9,752	14,317	4,301	4,145	13,681	20,085	6,033	3,109	10,260	15,064	4,525
	Industrial	0	0	0	0	9,516	21,840	53,338	9,632	7,137	16,380	40,004	7,224
	Open	3,031	12,289	6,795	5,420	176	715	396	315	176	715	396	315
	Residential	5,675	6,633	16,398	2,925	6,768	7,911	19,558	3,489	5,076	5,933	14,669	2,617
	Total	**11,667**	**28,682**	**37,527**	**12,649**	**20,661**	**44,218**	**93,513**	**19,501**	**15,540**	**33,342**	**70,234**	**14,705**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	3,407	4,377	8,467	1,930	3,067	3,941	7,623	1,738	3,067	3,941	7,623	1,738
BFC60	Highway	8,025	26,485	38,883	11,680	9,062	29,909	43,911	13,190	9,062	29,909	43,911	13,190
	Industrial	0	0	0	0	6,445	14,791	36,124	6,523	6,445	14,791	36,124	6,523
	Open	2,083	8,446	4,670	3,725	767	3,111	1,720	1,372	767	3,111	1,720	1,372
	Residential	14,300	16,715	41,322	7,372	17,809	20,817	51,463	9,180	17,809	20,817	51,463	9,180
	Total	**27,815**	**56,023**	**93,343**	**24,707**	**37,151**	**72,569**	**140,840**	**32,004**	**37,151**	**72,569**	**140,840**	**32,004**
	Commercial	3,203	4,115	7,959	1,815	1,280	1,645	3,182	725	1,280	1,645	3,182	725
BFC61	Highway	12,368	40,820	59,929	18,002	11,650	38,450	56,450	16,957	11,650	38,450	56,450	16,957
	Industrial	0	0	0	0	3,989	9,156	22,361	4,038	3,989	9,156	22,361	4,038
	Open	**777**	3,150	1,742	1,389	306	1,241	686	547	306	1,241	686	547
	Residential	16,663	19,476	48,149	8,589	17,131	20,024	49,503	8,831	17,131	20,024	49,503	8,831
	Total	**33,010**	**67,560**	**117,779**	**29,795**	**34,357**	**70,515**	**132,181**	**31,099**	**34,357**	**70,515**	**132,181**	**31,099**
	Commercial	1,819	2,338	4,521	1,031	7,903	10,153	19,639	4,478	5,927	7,615	14,729	3,358
BFD70	Highway	4,910	16,205	23,791	7,147	6,186	20,417	29,975	9,004	4,640	15,313	22,481	6,753
	Industrial	440	1,010	2,466	445	1,492	3,424	8,362	1,510	1,119	2,568	6,271	1,132
	Open	3,578	14,506	8,021	6,397	700	2,837	1,569	1,251	700	2,837	1,569	1,251
	Residential	4,276	4,998	12,356	2,204	6,725	7,860	19,432	3,466	5,044	5,895	14,574	2,600
	Total	**15,023**	**39,056**	**51,156**	**17,224**	**23,005**	**44,692**	**78,977**	**19,710**	**17,429**	**34,228**	**59,625**	**15,095**
	Commercial	1,910	2,454	4,746	1,082	4,968	6,382	12,345	2,815	4,968	6,382	12,345	2,815
BFD71	Highway	8,656	28,567	41,941	12,599	9,015	29,755	43,684	13,122	9,015	29,755	43,684	13,122
	Industrial	66	151	368	66	387	888	2,169	392	387	888	2,169	392
	Open	3,090	12,527	6,927	5,525	649	2,630	1,455	1,160	649	2,630	1,455	1,160
	Residential	9,068	10,599	26,203	4,674	13,762	16,085	39,766	7,094	13,762	16,085	39,766	7,094
	Total	**22,789**	**54,297**	**80,184**	**23,946**	**28,780**	**55,741**	**99,419**	**24,583**	**28,780**	**55,741**	**99,419**	**24,583**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	142	182	352	80	1,664	2,138	4,135	943	1,664	2,138	4,135	943
BFD72	Highway	10,098	33,329	48,931	14,699	9,224	30,442	44,693	13,425	9,224	30,442	44,693	13,425
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	1,104	4,475	2,475	1,974	670	2,718	1,503	1,199	670	2,718	1,503	1,199
	Residential	14,738	17,226	42,587	7,597	15,288	17,869	44,176	7,881	15,288	17,869	44,176	7,881
	Total	**26,081**	**55,212**	**94,344**	**24,349**	**26,846**	**53,167**	**94,507**	**23,448**	**26,846**	**53,167**	**94,507**	**23,448**
	Commercial	513	659	1,275	291	1,116	1,434	2,773	632	1,116	1,434	2,773	632
BFD73	Highway	7,137	23,554	34,580	10,388	6,187	20,419	29,978	9,005	6,187	20,419	29,978	9,005
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	533	2,160	1,195	953	407	1,650	913	728	407	1,650	913	728
	Residential	9,663	11,294	27,922	4,981	10,061	11,760	29,074	5,187	10,061	11,760	29,074	5,187
	Total	**17,845**	**37,667**	**64,972**	**16,612**	**17,771**	**35,264**	**62,738**	**15,552**	**17,771**	**35,264**	**62,738**	**15,552**
	Commercial	3,341	4,293	8,304	1,893	5,189	6,667	12,895	2,940	5,189	6,667	12,895	2,940
BFD74	Highway	8,000	26,403	38,763	11,644	6,697	22,102	32,449	9,748	6,697	22,102	32,449	9,748
	Industrial	649	1,489	3,637	657	670	1,538	3,757	678	670	1,538	3,757	678
	Open	587	2,379	1,316	1,049	250	1,015	561	448	250	1,015	561	448
	Residential	8,379	9,793	24,212	4,319	8,560	10,005	24,734	4,412	8,560	10,005	24,734	4,412
	Total	**20,956**	**44,358**	**76,231**	**19,563**	**21,366**	**41,328**	**74,397**	**18,226**	**21,366**	**41,328**	**74,397**	**18,226**
	Commercial	35	45	87	20	1,147	1,474	2,851	650	1,147	1,474	2,851	650
BFD75	Highway	4,163	13,739	20,171	6,059	2,632	8,686	12,752	3,831	2,632	8,686	12,752	3,831
	Industrial	1,271	2,916	7,122	1,286	1,028	2,360	5,763	1,041	1,028	2,360	5,763	1,041
	Open	1,919	7,782	4,303	3,432	1,589	6,444	3,563	2,842	1,589	6,444	3,563	2,842
	Residential	2,889	3,377	8,348	1,489	4,000	4,675	11,558	2,062	4,000	4,675	11,558	2,062
	Total	**10,277**	**27,858**	**40,030**	**12,286**	**10,396**	**23,639**	**36,487**	**10,425**	**10,396**	**23,639**	**36,487**	**10,425**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	861	1,106	2,140	488	1,558	2,002	3,873	883	1,558	2,002	3,873	883
BFD76	Highway	5,027	16,593	24,361	7,318	4,173	13,772	20,219	6,074	4,173	13,772	20,219	6,074
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	455	1,847	1,021	814	321	1,301	719	574	321	1,301	719	574
	Residential	6,721	7,856	19,422	3,465	7,015	8,200	20,272	3,616	7,015	8,200	20,272	3,616
	Total	**13,065**	**27,402**	**46,944**	**12,085**	**13,067**	**25,275**	**45,083**	**11,147**	**13,067**	**25,275**	**45,083**	**11,147**
	Commercial	237	304	588	134	2,388	3,068	5,933	1,353	2,388	3,068	5,933	1,353
BFD77	Highway	4,484	14,800	21,729	6,527	3,020	9,969	14,636	4,396	3,020	9,969	14,636	4,396
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	1,307	5,301	2,931	2,338	780	3,164	1,749	1,395	780	3,164	1,749	1,395
	Residential	1,428	1,670	4,127	736	2,058	2,405	5,947	1,061	2,058	2,405	5,947	1,061
	Total	**7,457**	**22,075**	**29,376**	**9,735**	**8,246**	**18,606**	**28,265**	**8,206**	**8,246**	**18,606**	**28,265**	**8,206**
	Commercial	62	79	153	35	545	700	1,354	309	409	525	1,016	232
WC10	Highway	1,448	4,780	7,018	2,108	3,185	10,511	15,432	4,636	2,389	7,883	11,574	3,477
	Industrial	785	1,803	4,403	795	9,695	22,250	54,340	9,813	7,271	16,688	40,755	7,360
	Open	5,684	23,046	12,743	10,164	64	261	144	115	64	261	144	115
	Residential	0	0	0	0	9,655	11,285	27,900	4,977	7,241	8,464	20,925	3,733
	Total	**7,979**	**29,707**	**24,317**	**13,102**	**23,144**	**45,008**	**99,171**	**19,850**	**17,374**	**33,821**	**74,414**	**14,916**
	Commercial	0	0	0	0	13	17	33	8	10	13	25	6
WC11	Highway	647	2,134	3,133	941	2,227	7,351	10,792	3,242	1,670	5,513	8,094	2,431
	Industrial	31	71	174	31	1,038	2,382	5,817	1,050	778	1,786	4,363	788
	Open	4,895	19,845	10,974	8,752	235	951	526	419	235	951	526	419
	Residential	532	622	1,538	274	13,669	15,977	39,497	7,046	10,251	11,982	29,623	5,284
	Total	**6,104**	**22,672**	**15,818**	**9,999**	**17,182**	**26,678**	**56,666**	**11,765**	**12,945**	**20,246**	**42,631**	**8,929**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	0	0	0	0	2	3	6	1	2	2	4	1
WC12	Highway	885	2,919	4,286	1,288	1,858	6,131	9,001	2,704	1,393	4,598	6,751	2,028
	Industrial	0	0	0	0	5,584	12,815	31,298	5,652	4,188	9,611	23,473	4,239
	Open	6,910	28,015	15,491	12,355	208	845	467	373	208	845	467	373
	Residential	471	551	1,362	243	16,918	19,775	48,887	8,721	12,689	14,831	36,666	6,541
	Total	**8,265**	**31,485**	**21,139**	**13,886**	**24,570**	**39,569**	**89,659**	**17,451**	**18,480**	**29,888**	**67,361**	**13,181**
	Commercial	0	0	0	0	15	19	37	8	11	14	28	6
WC13	Highway	1,916	6,325	9,286	2,789	2,972	9,810	14,402	4,326	2,229	7,357	10,802	3,245
	Industrial	390	895	2,186	395	19,423	44,576	108,866	19,659	14,567	33,432	81,649	14,744
	Open	5,526	22,405	12,389	9,881	55	222	123	98	55	222	123	98
	Residential	0	0	0	0	2,216	2,591	6,404	1,142	1,662	1,943	4,803	857
	Total	**7,832**	**29,625**	**23,861**	**13,065**	**24,681**	**57,217**	**129,832**	**25,234**	**18,525**	**42,969**	**97,404**	**18,950**
	Commercial	39	50	96	22	59	76	146	33	44	57	110	25
WC14	Highway	182	601	882	265	2,288	7,552	11,087	3,331	1,716	5,664	8,316	2,498
	Industrial	0	0	0	0	3,132	7,188	17,554	3,170	2,349	5,391	13,166	2,377
	Open	3,835	15,551	8,599	6,858	621	2,518	1,393	1,111	621	2,518	1,393	1,111
	Residential	1,013	1,184	2,928	522	8,599	10,051	24,848	4,433	6,449	7,538	18,636	3,325
	Total	**5,069**	**17,385**	**12,505**	**7,667**	**14,699**	**27,385**	**55,029**	**12,077**	**11,180**	**21,168**	**41,620**	**9,336**
	Commercial	1,805	2,319	4,486	1,023	1,911	2,455	4,749	1,083	1,433	1,841	3,562	812
WC15	Highway	996	3,289	4,828	1,450	5,845	19,293	28,324	8,508	4,384	14,469	21,243	6,381
	Industrial	0	0	0	0	3,750	8,607	21,019	3,796	2,813	6,455	15,765	2,847
	Open	8,186	33,190	18,353	14,637	1,648	6,682	3,695	2,947	1,648	6,682	3,695	2,947
	Residential	1,266	1,479	3,658	652	18,818	21,995	54,377	9,700	14,113	16,496	40,782	7,275
	Total	**12,253**	**40,277**	**31,324**	**17,763**	**31,973**	**59,032**	**112,164**	**26,034**	**24,391**	**45,945**	**85,047**	**20,262**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	35	44	86	20	476	612	1,183	270	357	459	888	202
WC16	Highway	2,127	7,021	10,308	3,097	1,610	5,315	7,803	2,344	1,208	3,986	5,853	1,758
	Industrial	3,963	9,096	22,215	4,012	7,633	17,518	42,782	7,726	5,725	13,138	32,087	5,794
	Open	3,411	13,829	7,647	6,099	99	403	223	178	99	403	223	178
	Residential	623	728	1,801	321	8,259	9,653	23,865	4,257	6,194	7,240	17,898	3,193
	Total	**10,159**	**30,719**	**42,057**	**13,548**	**18,078**	**33,501**	**75,856**	**14,774**	**13,583**	**25,226**	**56,948**	**11,125**
	Commercial	15	20	38	9	1,345	1,729	3,344	762	1,009	1,296	2,508	572
WC17	Highway	1,941	6,407	9,406	2,825	3,385	11,173	16,403	4,927	2,539	8,379	12,302	3,696
	Industrial	1,587	3,643	8,898	1,607	16,925	38,842	94,861	17,130	12,693	29,131	71,146	12,848
	Open	8,099	32,837	18,158	14,482	839	3,402	1,881	1,500	839	3,402	1,881	1,500
	Residential	586	685	1,692	302	9,959	11,640	28,777	5,133	7,469	8,730	21,583	3,850
	Total	**12,229**	**43,592**	**38,192**	**19,225**	**32,453**	**66,785**	**145,265**	**29,453**	**24,549**	**50,939**	**109,419**	**22,465**
	Commercial	0	0	0	0	16	20	39	9	12	15	29	7
WC18	Highway	735	2,426	3,562	1,070	5,246	17,315	25,421	7,636	3,935	12,986	19,066	5,727
	Industrial	0	0	0	0	1,261	2,893	7,065	1,276	945	2,170	5,299	957
	Open	5,124	20,774	11,487	9,162	1,039	4,212	2,329	1,858	1,039	4,212	2,329	1,858
	Residential	5,811	6,792	16,791	2,995	15,428	18,033	44,581	7,953	11,571	13,525	33,436	5,965
	Total	**11,670**	**29,992**	**31,841**	**13,227**	**22,989**	**42,473**	**79,436**	**18,731**	**17,502**	**32,908**	**60,159**	**14,513**
	Commercial	700	899	1,739	397	50	64	124	28	50	64	124	28
WC19	Highway	6,816	22,495	33,026	9,921	9,959	32,868	48,255	14,495	9,959	32,868	48,255	14,495
	Industrial	0	0	0	0	0	0	0	0	0	0	0	0
	Open	2,365	9,588	5,302	4,228	933	3,783	2,092	1,668	933	3,783	2,092	1,668
	Residential	13,280	15,523	38,376	6,846	16,674	19,489	48,182	8,595	16,674	19,489	48,182	8,595
	Total	**23,161**	**48,505**	**78,442**	**21,391**	**27,616**	**56,204**	**98,653**	**24,787**	**27,616**	**56,204**	**98,653**	**24,787**

Sub Basin	Land Use	EXISTING CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE CONDITIONS Pollutant (TSS) Loading By Rainfall Season (lbs)				FUTURE WITH ISWM 70% Pollutant (TSS) Loading By Rainfall Season (lbs)			
		1	2	3	4	1	2	3	4	1	2	3	4
	Commercial	1,126	1,447	2,799	638	1,495	1,921	3,715	847	1,495	1,921	3,715	847
WC20	Highway	3,367	11,114	16,317	4,902	7,479	24,683	36,238	10,886	7,479	24,683	36,238	10,886
	Industrial	1,113	2,554	6,238	1,126	1,499	3,441	8,404	1,518	1,499	3,441	8,404	1,518
	Open	3,509	14,227	7,867	6,274	952	3,860	2,134	1,702	952	3,860	2,134	1,702
	Residential	7,284	8,513	21,047	3,755	12,558	14,679	36,289	6,474	12,558	14,679	36,289	6,474
	Total	**16,399**	**37,855**	**54,267**	**16,695**	**23,983**	**48,583**	**86,780**	**21,426**	**23,983**	**48,583**	**86,780**	**21,426**
	Commercial	2,288	2,940	5,686	1,296	6,143	7,893	15,266	3,481	6,143	7,893	15,266	3,481
WC21	Highway	8,551	28,221	41,433	12,446	8,622	28,457	41,780	12,550	8,622	28,457	41,780	12,550
	Industrial	624	1,433	3,499	632	0	0	0	0	0	0	0	0
	Open	2,382	9,657	5,340	4,259	2,084	8,449	4,672	3,726	2,084	8,449	4,672	3,726
	Residential	11,492	13,432	33,208	5,924	9,593	11,213	27,720	4,945	9,593	11,213	27,720	4,945
	Total	**25,337**	**55,683**	**89,166**	**24,557**	**26,442**	**56,011**	**89,438**	**24,702**	**26,442**	**56,011**	**89,438**	**24,702**
	TOTAL WATERSHED	**935,230**	**2,504,454**	**3,148,510**	**1,104,361**	**1,536,896**	**2,916,779**	**5,655,309**	**1,286,205**	**1,311,525**	**2,515,762**	**4,777,553**	**1,109,387**

Appendix D – Streambank Protection Analysis

Channel erosion is effected by such factors as flow regime, climate, and types of channel beds and bank material. Within a specific stream reach, change in flow rate can be considered to be the determining factor when comparing erosion losses subject to different flow conditions. The channel erosion concepts presented in the technical paper *Erodibility of Urban Bedrock and Alluvial Channels, North Texas* (Allen, Peter M., et.al. Journal of The American Water Resources Association, Vol.38, No. 5, October 2002) were used to quantify the degree of potential channel erosion in the study portion of Big Fossil Creek for future conditions *without* and *with* iSWM design criteria.

The technical paper found that approximately 75 percent of channels in North Texas basins have alluvial banks with gravel or rock bottoms and the active channel width and depth could be determined through regression analysis. From the extensive field survey results, regression equations were developed to determine the active channel width (ACW) and active channel depth (ACD) based on the flow rate of the channel. These relationships are as follows:

$$ACW = 1.28 * Q^{0.48} \quad , \quad R^2 = 0.83$$
$$ACD = 0.208 * Q^{0.44} \quad , \quad R^2 = 0.91$$

(R= regression coefficient, Q expressed as 1-year event)

To determine the relative effects of future conditions *without* iSWM and future conditions *with* iSWM scenarios on erosion losses of the channel, two cross section locations along the main stem of Big Fossil Creek within the hydraulic study area were selected (See Figure D-1). Cross Section location 1 is located 500 feet upstream of Glenview Drive. Cross Section location 2 is located approximately 1700 feet upstream of Haltom Road. Figures D-2 and D-3 were obtained during field visits to Cross Section 1 and 2, respectively. The bed and bank materials show a dominance of gravel bed and alluvial channel bank. Figure D-3 shows existing channel erosion.

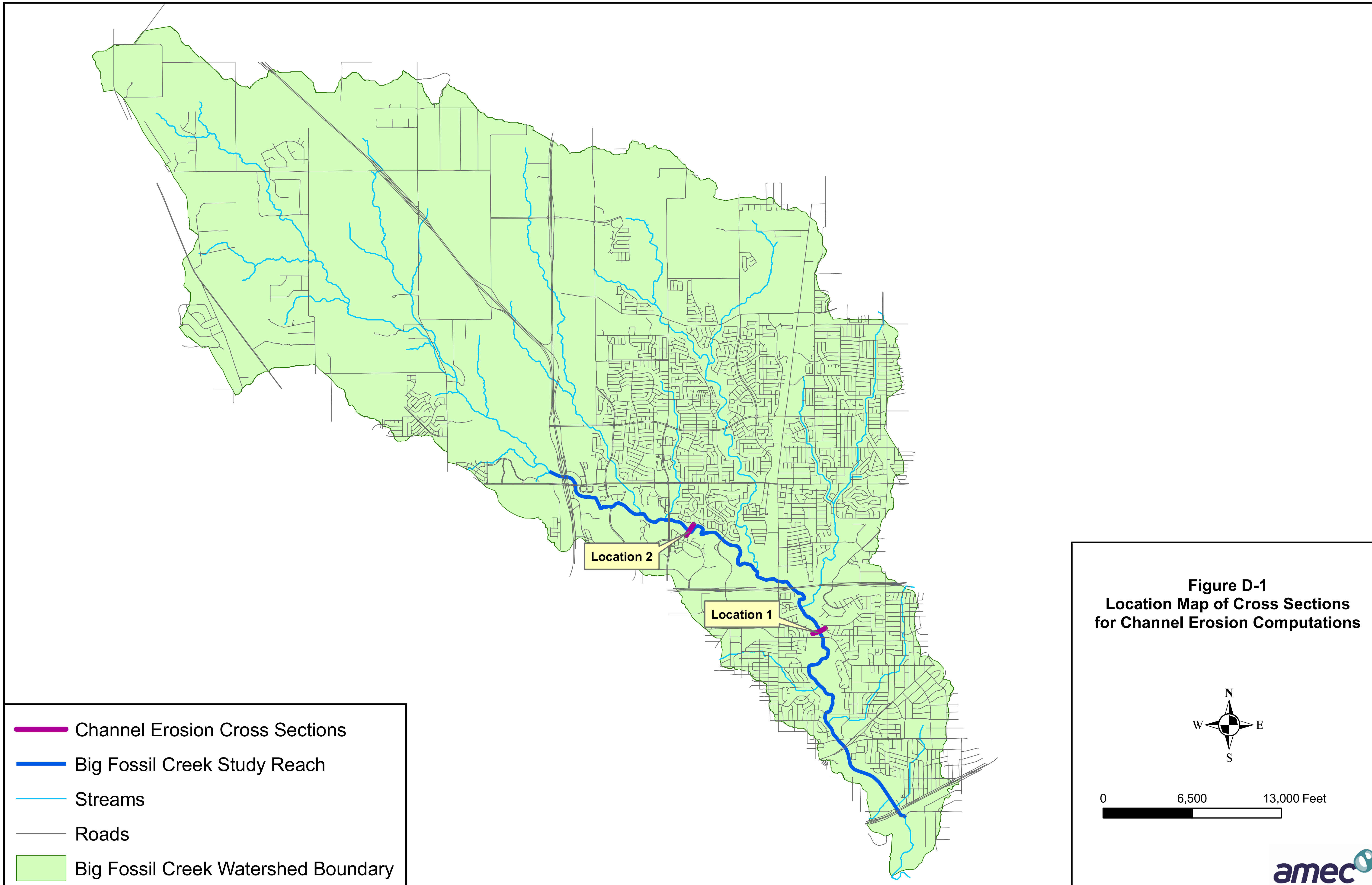


Figure D-1
Location Map of Cross Sections for Channel Erosion Computations

Figure D-2. Cross Section location 1 - 500 feet upstream of Glenview Drive

Figure D-3. Cross Section location 2 - 1,700 feet upstream of Haltom Road

The drainage area and corresponding frequency discharges for the 1-year storm event for the three watershed scenarios, at each cross section location, were determined from the hydrologic analysis. The cross sections were located in the field and photographed and the channel sections in the available hydraulic models were identified. The regression equations outlined above were used to calculate active channel width (ACW) and active channel depth (ACD) for the three watershed scenarios. Results of the analysis are presented in Table D-1.

Table D-1. Potential Channel Erosion for Future, and Future-iSWM condition

Description	Parameters	1-Yr Event Future	1-Yr Event Future-iSWM
Location 1 Drainage Area, 50.63 (mi^2)	**Discharge (cfs)**	8,765	5,034
	Active channel Width (ft)	99.9	76.6
	Active Channel Depth (ft)	11.3	8.8
	Area of Channel (ft^2)	1129	678
Location 2 Drainage Area, 31.77 (mi^2)	**Discharge (cfs)**	5,798	2,564
	Active channel Width (ft)	82.0	55.4
	Active Channel Depth (ft)	9.4	6.6
	Area of Channel (ft^2)	772	364

Channel Impact Model Results

The data from the analysis in Table D-1 can be used to quantify the potential increase in channel erosion in the study reach. It is clear that applying iSWM design criteria would mitigate the potential for channel erosion, since the model shows that the active channel size without iSWM conditions is significantly greater than the active channel size with application of iSWM design criteria. However, if iSWM design criteria are not applied, the potential for erosion in the study area is significant. Assuming cross section locations 1 and 2 are typical of the 4.75 miles of the upper and lower portion of the study reach (total study reach length of 9.5 miles), and the channel sections could be represented accurately for this calculation as a rectangles, the potential increase in channel erosion under future conditions without iSWM compared to future conditions with iSWM is equal to 797,916 cu yards of material, or 83,991 cu yards per linear mile of stream.